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Manifesto

Advanced Interdisciplinary Care in periOperative Practice (AICO Journal) is an international peer-reviewed journal dedicated to research, innovation, and professional practice across the perioperative continuum. The journal promotes dissemination of knowledge related to pre-operative, intra-operative, and post-operative care, supporting evidence-based practice, patient safety, interdisciplinary collaboration, and innovation in perioperative healthcare.

The journal particularly welcomes studies exploring perioperative interventions, models of care, healthcare systems, technological innovation, and organizational approaches, using rigorous research designs appropriate to clinical and interdisciplinary inquiry. AICO Journal publishes original peer-reviewed contributions of interest to the international perioperative, surgical, nursing, anesthesia, and healthcare community.

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AICO

AICO – Associazione Italiana Infermieri di Camera Operatoria is the Italian scientific association dedicated to operating room and perioperative nursing. It brings together nurses and healthcare professionals involved in surgical and perioperative care to support professional development, scientific research, and interdisciplinary collaboration. The association aims to improve the quality and safety of perioperative care by promoting education, research, professional standards, and the dissemination of evidence-based clinical practices.

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Advanced Interdisciplinary Care in **periOperative practice**

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One Step Forward

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One Step Forward

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«This moment is also the beginning of a new chapter, rich in enthusiasm and in aims ... yet it also carries uncertainties and misgivings about the future, about the difficulty of retaining, over time, the capacity to grasp what is being asked and to adapt to needs as they emerge.»

Anna Maria Mattiassich,
introduction to the first issue, 1989
(translated from the Italian)

For more than thirty years, within our professional community, AICO has meant one thing: Associazione Italiana Infermieri di Camera Operatoria, the Italian Association of Operating Room Nurses. From today, those same four letters also stand for *Advanced Interdisciplinary Care in periOperative practice*.

This is neither wordplay nor an exercise in rebranding. It is one stage in a journey the association has made slowly, one step at a time, and that journey is worth retracing.

Thirty-seven years ago, in the words quoted above, the first step was taken: the decision to give ourselves a written voice. It was a less obvious choice than it may appear today, and those who made it presented it without any guarantee as to how it would end. What followed was a bulletin, then an association journal, which for more than thirty years carried accounts of operating room practice, procedures, reflections and congress proceedings. The cover, title page, and opening presentation of that first issue are reproduced in Figure 1. That work would be easy to underestimate now; in fact it taught a professional community the habit of writing

down what it knew. It taught colleagues who were not researchers by profession that their daily practice deserved to be described, discussed and challenged.

The steps that followed led to a continuing, accredited education programme delivered across the country. To sustained work on good practice and perioperative safety. To a presence at the tables where competencies, post-basic education, certification and the recognition of nursing expertise in the surgical setting are debated. To public positions, some of them uncomfortable, taken whenever that expertise was called into question. These were the years in which AICO gradually ceased to be merely a meeting point for professionals and began to behave as a scientific society: that is, as a body that does not simply represent a profession, but takes responsibility for producing its knowledge. For a scientific society, producing knowledge is not an ancillary activity. It is a responsibility. It means transforming what happens every day in clinical practice into testable questions, shareable data, and evidence capable of changing that practice in return. This is the cycle through which experience becomes science, and science returns to care.

The step we take today follows naturally from that journey.

This journal is founded with a wider remit than the one we come from. Alongside nurses, it will host the other professions involved along the surgical pathway, and rightly so, since no outcome in the operating room depends on a single profession. In this perspective, interdisciplinarity is not simply the presence of different professions within the same journal.

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It is a way of addressing problems that have long ceased to belong to any single discipline. Some of the most important questions in contemporary perioperative care arise precisely at the boundaries between disciplines. But the boundary that genuinely shifts here is a different one, and it concerns us.

For decades our professional identity gathered around a physical space: the operating room, its threshold, its rules. The operating room was, as was written back then, «the birthplace and at the same time the guiding purpose» of those early pages. It remains the birthplace; the guiding purpose, however, has widened. Focusing on that space was necessary at the time, because it was there that a specialist competence was built which needed to be recognised and defended. Today, though, we know that the outcome for the person in our care is determined long before that door opens and long after it closes: in preoperative assessment, in preparation, in the prevention of surgical site infection, in pain management, in recovery, in the continuity of care with wards and community services. This is what perioperative means: not a place, but a pathway. Shifting our gaze from the room to the whole pathway does not take the operating room nurse away from their field. But it is also something more: an emerging scientific field in which clinical, organisational, technological, and human dimensions must be studied together to understand what no single discipline can explain in isolation. This is the space in which AICO Journal intends to position itself. On the contrary, it restores the true scale of their contribution, which neither begins nor ends at the door of the surgical suite.

The environment in which this expertise is exercised is also changing. Robotics, artificial intelligence, digital systems, new devices, simulation, and the growing availability of data are transforming the operating room into one of the most technologically complex environments in healthcare. Yet innovation alone does not necessarily produce better care. It must be studied, evaluated, and integrated into practice. The future of perioperative care will therefore depend not only on the technologies we are able to introduce, but on the scientific questions we are able to ask about them.

There is also the economic dimension, and it should not be concealed. The journal will be published in full open access, with no subscription barrier for readers and no charge

whatsoever to those who publish: no submission fee, no article processing charge. Authors retain copyright in their own work. This means, quite simply, that the costs are borne by the association. It is a real and deliberate investment, added to those made in education and organisation over past years, and the reason we have committed to it is that the expected return is not measured in the balance sheet. It is measured in professional culture.

A community that publishes under peer review learns something it cannot learn elsewhere: it learns to frame a research question, to tell an opinion from a finding, to support a claim with evidence and to withdraw it when the evidence does not hold. It learns to read the work of others critically, because whoever writes will sooner or later be asked to review. It learns that clinical experience alone is not transferable knowledge: it becomes so when it is described with method. This learning does not concern only those who will publish. It feeds back into everyone's practice, because it changes the way a profession discusses itself in its units, in its committees, in the places where it is decided what an operating room nurse may and must do. A scientific journal, therefore, is not merely a place where a community preserves what it knows. It is also where, through method and critical dialogue, that community determines what it is prepared to recognise as reliable knowledge. A journal does not merely document a discipline: it helps to build it. And it concerns above all those who are just arriving.

The new generations enter the surgical setting with master's degrees, specialist qualifications, doctorates and expectations about research, and they know that work which cannot be traced in an international database does not, for assessment purposes, exist at all. Having a recognised publishing venue means offering them somewhere to build a career without having to migrate to journals that do not speak to their practice. It means retaining expertise instead of dispersing it.

All of this, to be clear, is a demand for commitment addressed to the community of nurses working in the surgical setting. Is it demanding? Yes. But it is precisely that commitment, and that effort, which generates value: a word so heavily used that it has worn thin, and one that acquires substance only when someone takes on the cost of producing it. This journal is our proposal for doing so.

It is worth saying, too, what this journal is not. It is not a badge the association pins to its chest. It is not a space reserved for members: the quality of the work will be the sole criterion for acceptance, and contributions are expected from any country. And it is not an achievement already secured. Indexing in the major bibliographic databases is a stated objective, not an accomplished fact, and it will depend entirely on the regularity of our issues, the rigour of our reviews and the number of sound manuscripts we manage to attract.

On this last point the editorial becomes an appeal. A journal is not made by a publisher or by a committee: it is made by the authors who entrust their work to it and by the reviewers who agree to read that work properly.

This first issue is one more step forward for the association, but it is also the first step of a different journey, one that no longer belongs to us alone. Colleagues in other countries who recognise themselves in this field are invited to submit their work and to leave their mark on these pages: every article published will be a step taken by someone who, elsewhere, has asked the same questions we have. Because from the moment a scientific question is shared, it ceases to belong solely to the institution or country in which it originated. It enters a wider conversation. That is the conversation these pages intend to host.

The text that opened those first pages took its leave of readers by hoping that their shared effort would find an audience. It is the right expression, and we gladly take it up again: that effort is more widely shared today than it was then, because the readership we now address will not stop at our national borders.

The road ahead is still long, but we will not be walking it alone.

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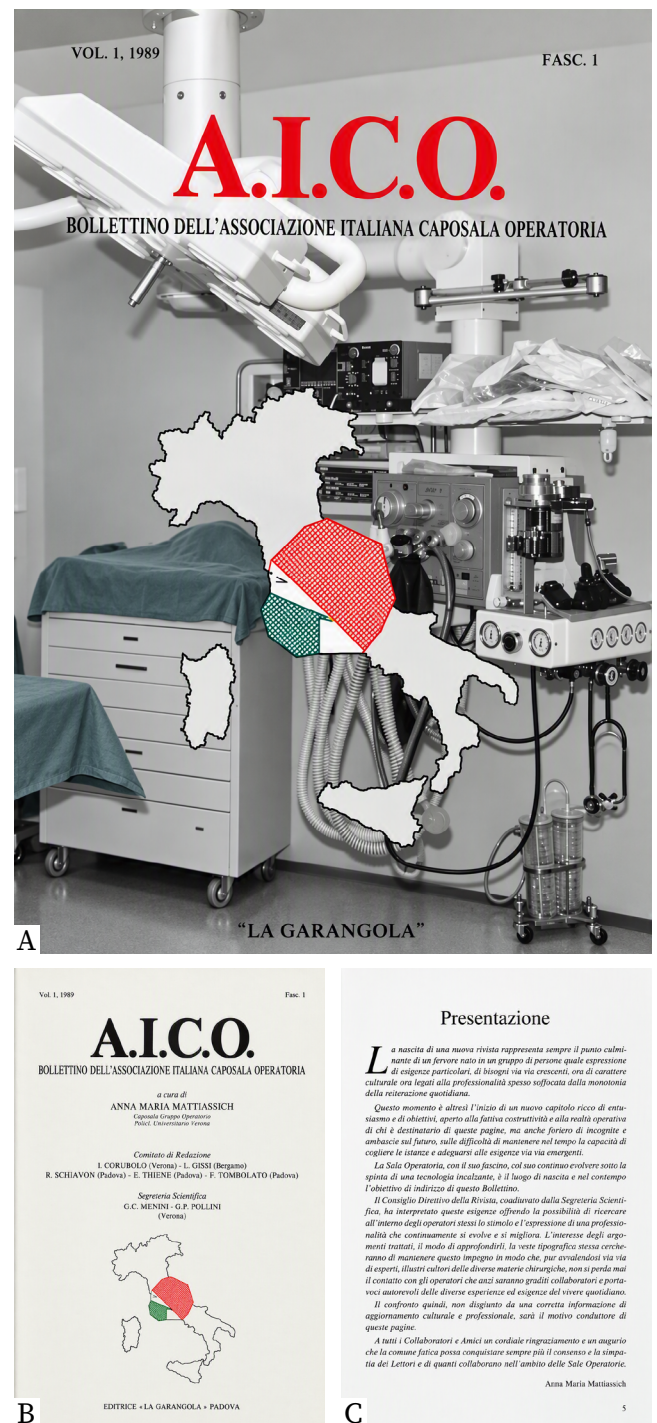


Figure 1. Historical material from the first issue of the A.I.C.O. Bulletin (Vol. 1, Fasc. 1, 1989): (A) cover; (B) title page and editorial board; (C) opening 'Presentazione' by Anna Maria Mattiassich. The passage quoted at the beginning of this editorial is taken from the text shown in panel C.

Un Passo Avanti

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«Questo momento è altresì l'inizio di un nuovo capitolo ricco di entusiasmo e di obiettivi [...] ma anche foriero di incognite e ambascie sul futuro, sulle difficoltà di mantenere nel tempo la capacità di cogliere le istanze e adeguarsi alle esigenze via via emergenti.»

Anna Maria Mattiassich,
Presentazione al primo numero, 1989

Da oltre trent'anni, all'interno della nostra comunità professionale, AICO ha significato una cosa: Associazione Italiana Infermieri di Camera Operatoria. Da oggi, quelle stesse quattro lettere significano anche Advanced Interdisciplinary Care in periOperative Practice.

Non si tratta né di un gioco di parole né di un esercizio di rebranding. È una tappa di un percorso che l'associazione ha compiuto lentamente, un passo alla volta, e vale la pena ripercorrere quel percorso.

Trentasette anni fa, nelle parole citate sopra, fu compiuto il primo passo: la decisione di darci una voce scritta. Era una scelta meno ovvia di quanto possa apparire oggi, e coloro che la fecero la presentarono senza alcuna garanzia su come sarebbe finita. Ne seguirono un bollettino, poi una rivista associativa che, per oltre trent'anni, ha raccolto testimonianze della pratica in sala operatoria, procedure, riflessioni e atti congressuali. La copertina, il frontespizio e la presentazione introduttiva di quel primo numero sono riprodotti nella Figura 1. Quel lavoro sarebbe facile da sottovalutare oggi; in realtà, insegnò a una comunità professionale l'abitudine di mettere per iscritto ciò che sapeva. Insegnò a colleghi che

non erano ricercatori di professione che la loro pratica quotidiana meritava di essere descritta, discussa e messa in discussione.

I passi successivi portarono a un programma di formazione continua accreditata erogato in tutto il Paese. A un lavoro costante sulle buone pratiche e sulla sicurezza perioperatoria. A una presenza ai tavoli nei quali vengono discusse le competenze, la formazione post-base, la certificazione e il riconoscimento dell'expertise infermieristica in ambito chirurgico. A prese di posizione pubbliche, alcune delle quali scomode, ogni volta che tale expertise veniva messa in discussione. Furono gli anni nei quali AICO cessò gradualmente di essere soltanto un punto di incontro per professionisti e iniziò a comportarsi come una società scientifica: vale a dire, come un organismo che non si limita a rappresentare una professione, ma si assume la responsabilità di produrne la conoscenza.

Per una società scientifica, produrre conoscenza non è un'attività accessoria. È una responsabilità. Significa trasformare ciò che accade ogni giorno nella pratica clinica in domande verificabili, dati condivisibili ed evidenze capaci, a loro volta, di modificare quella pratica. Questo è il ciclo attraverso il quale l'esperienza diventa scienza e la scienza ritorna alla cura.

Il passo che compiamo oggi deriva naturalmente da quel percorso.

Questa rivista nasce con un ambito più ampio rispetto a quello da cui proveniamo. Accanto agli infermieri, accoglierà le altre professioni coinvolte lungo il percorso chirurgico, ed è giusto che sia così, poiché nessun esito in sala operatoria dipende da una singola professione. In questa prospettiva, l'interdisciplinarietà non è semplicemente la presenza di professioni diverse

Finanziamenti: Questo editoriale non ha ricevuto finanziamenti esterni. **Conflitto di Interessi:** L'autore è Presidente di AICO – Associazione Italiana Infermieri di Camera Operatoria. Non sono dichiarati altri conflitti di interesse.

all'interno della stessa rivista.

È un modo di affrontare problemi che da tempo hanno cessato di appartenere a una singola disciplina. Alcune delle questioni più importanti dell'assistenza perioperatoria contemporanea sorgono precisamente ai confini tra le discipline. Ma il confine che qui cambia realmente è un altro, e riguarda noi.

Per decenni la nostra identità professionale si è raccolta attorno a uno spazio fisico: la sala operatoria, la sua soglia, le sue regole. La sala operatoria era, come veniva scritto allora, «il luogo di nascita e nel contempo l'obiettivo di indirizzo» di quelle prime pagine. Rimane il luogo di nascita; l'obiettivo di indirizzo, tuttavia, si è ampliato. Concentrarsi su quello spazio era necessario allora, perché era lì che si costruiva una competenza specialistica che aveva bisogno di essere riconosciuta e difesa.

Oggi, tuttavia, sappiamo che l'esito per la persona di cui ci prendiamo cura è determinato molto prima che quella porta si apra e molto dopo che si chiude: nella valutazione preoperatoria, nella preparazione, nella prevenzione delle infezioni del sito chirurgico, nella gestione del dolore, nel recupero, nella continuità assistenziale con i reparti e i servizi territoriali. Questo è ciò che significa perioperatorio: non un luogo, ma un percorso. Spostare il nostro sguardo dalla sala all'intero percorso non allontana l'infermiere di sala operatoria dal proprio ambito. Ma è anche qualcosa di più: un campo scientifico emergente nel quale le dimensioni cliniche, organizzative, tecnologiche e umane devono essere studiate insieme per comprendere ciò che nessuna singola disciplina può spiegare isolatamente. È questo lo spazio nel quale AICO Journal intende posizionarsi. Al contrario, restituisce la reale portata del loro contributo, che non inizia né termina alla porta del blocco operatorio.

Anche l'ambiente nel quale questa expertise viene esercitata sta cambiando. Robotica, intelligenza artificiale, sistemi digitali, nuovi dispositivi, simulazione e la crescente disponibilità di dati stanno trasformando la sala operatoria in uno degli ambienti tecnologicamente più complessi dell'assistenza sanitaria. Tuttavia, l'innovazione da sola non produce necessariamente una migliore assistenza. Deve essere studiata, valutata e integrata nella pratica. Il futuro dell'assistenza perioperatoria dipenderà quindi non soltanto dalle tecnologie che siamo in grado di introdurre, ma dalle domande scientifiche che siamo in grado di porre su di esse.

Esiste anche una dimensione economica, e non dovrebbe essere nascosta. La rivista sarà pubblicata in *open access*, senza barriere di abbonamento per i lettori e senza alcun costo per coloro che pubblicano: nessuna quota di sottomissione, nessun costo di elaborazione dell'articolo. Gli autori mantengono il copyright sul proprio lavoro. Questo significa, molto semplicemente, che i costi sono sostenuti dall'associazione. È un investimento reale e deliberato, che si aggiunge a quelli effettuati negli anni passati nella formazione e nell'organizzazione, e la ragione per cui abbiamo scelto di assumerci questo impegno è che il ritorno atteso non si misura nel bilancio. Si misura nella cultura professionale.

Una comunità che pubblica attraverso la peer review impara qualcosa che non può imparare altrove: impara a formulare una domanda di ricerca, a distinguere un'opinione da un risultato, a sostenere un'affermazione con le evidenze e a ritirarla quando le evidenze non reggono. Impara a leggere criticamente il lavoro degli altri, perché chiunque scriva prima o poi sarà chiamato a revisionare. Impara che l'esperienza clinica da sola non è conoscenza trasferibile: lo diventa quando viene descritta con metodo.

Questo apprendimento non riguarda soltanto coloro che pubblicheranno. Si riflette nella pratica di tutti, perché cambia il modo in cui una professione discute di sé nelle proprie unità, nei propri comitati, nei luoghi nei quali viene deciso ciò che un infermiere di sala operatoria può e deve fare. Una rivista scientifica, quindi, non è semplicemente un luogo nel quale una comunità conserva ciò che sa. È anche il luogo nel quale, attraverso il metodo e il dialogo critico, quella comunità determina ciò che è disposta a riconoscere come conoscenza affidabile. Una rivista non si limita a documentare una disciplina: contribuisce a costruirla.

Riguarda soprattutto coloro che stanno appena arrivando. Le nuove generazioni entrano nell'ambito chirurgico con master, qualifiche specialistiche, dottorati e aspettative nei confronti della ricerca, e sanno che un lavoro che non può essere rintracciato in una banca dati internazionale, ai fini della valutazione, non esiste affatto. Disporre di una sede editoriale riconosciuta significa offrire loro un luogo nel quale costruire una carriera senza dover migrare verso riviste che non parlano della loro pratica. Significa trattenere le competenze invece di disperderle.

Tutto questo, sia chiaro, è una richiesta di impegno rivolta alla comunità degli infermieri che

lavorano nell'ambito chirurgico. È impegnativo? Sì. Ma è precisamente quell'impegno, e quello sforzo, a generare valore: una parola utilizzata così tanto da essersi consumata, e che acquista sostanza soltanto quando qualcuno si assume il costo necessario per produrlo. Questa rivista è la nostra proposta per farlo.

Vale la pena dire, inoltre, ciò che questa rivista non è. Non è un distintivo che l'associazione si appunta sul petto. Non è uno spazio riservato ai soci: la qualità del lavoro sarà l'unico criterio di accettazione, e sono attesi contributi da qualsiasi Paese. E non è un risultato già acquisito. L'indicizzazione nelle principali banche dati bibliografiche è un obiettivo dichiarato, non un fatto compiuto, e dipenderà interamente dalla regolarità dei nostri fascicoli, dal rigore delle nostre revisioni e dal numero di manoscritti solidi che riusciremo ad attrarre.

Su quest'ultimo punto l'editoriale diventa un appello. Una rivista non è fatta da un editore o da un comitato: è fatta dagli autori che le affidano il proprio lavoro e dai revisori che accettano di leggere quel lavoro adeguatamente.

Questo primo fascicolo è un ulteriore passo avanti per l'associazione, ma è anche il primo passo di un percorso diverso, che non appartiene più soltanto a noi. I colleghi di altri Paesi che si riconoscono in questo ambito sono invitati a sottoporre il proprio lavoro e a lasciare il proprio segno su queste pagine: ogni articolo pubblicato sarà un passo compiuto da qualcuno che, altrove, si è posto le stesse domande che ci siamo posti noi. Perché dal momento in cui una domanda scientifica viene condivisa, cessa di appartenere esclusivamente all'istituzione o al Paese nel quale ha avuto origine. Entra in una conversazione più ampia. È questa la conversazione che queste pagine intendono ospitare.

Il testo che apriva quelle prime pagine si congedava dai lettori con l'auspicio che il loro sforzo condiviso trovasse un pubblico. È l'espressione giusta, e la riprendiamo volentieri: quello sforzo è oggi più ampiamente condiviso di quanto non fosse allora, perché il pubblico al quale ci rivolgiamo oggi non si fermerà ai nostri confini nazionali.

La strada davanti a noi è ancora lunga, ma non la percorreremo da soli.

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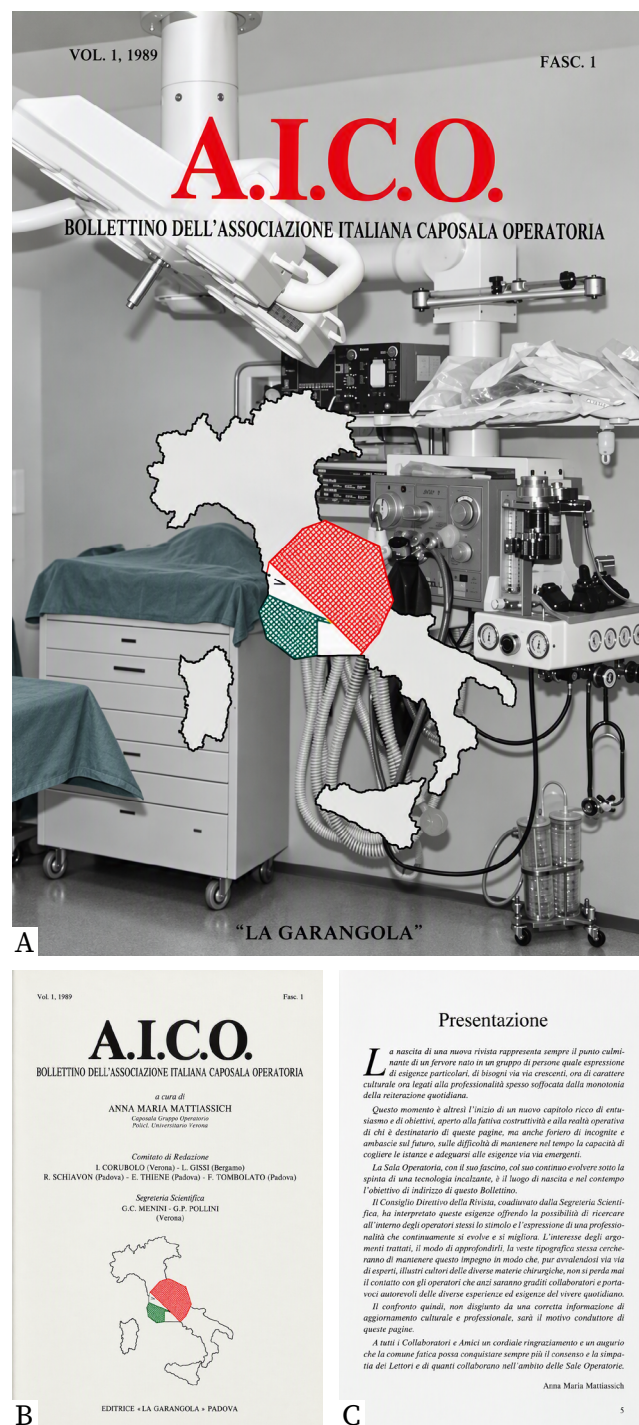


Figura 1. Materiale storico tratto dal primo numero del Bollettino A.I.C.O. (Vol. 1, Fasc. 1, 1989): (A) copertina; (B) frontespizio e comitato di redazione; (C) Presentazione introduttiva di Anna Maria Mattiassich. Il passaggio citato all'inizio di questo editoriale è tratto dal testo mostrato nel pannello C.

The Role of Artificial Intelligence and the Nurse Manager in Operating Room Flow Management: A Descriptive Study

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Abstract

Introduction. Operating room flow management represents a major challenge for contemporary healthcare systems, with implications for operational efficiency, quality of care, patient safety, and organizational well-being. Artificial intelligence (AI) may offer opportunities to optimize surgical planning, reduce waiting times, and improve coordination within operating rooms. In parallel, the Nurse Manager (NM), with advanced competencies in Operating Room Management, may play an important role in facilitating technological and organizational innovation. This descriptive study explored Italian operating room nurses' knowledge and perceptions regarding the use of AI and the contribution of the NM to operating room flow management, with particular attention to perceived opportunities and implementation barriers.

Methods. A structured questionnaire was administered to 94 operating room nurses working in 40 healthcare organizations across 13 Italian regions. The survey investigated professional experience, knowledge and perceptions of AI-based operating room management technologies, perceived barriers to implementation, willingness to undertake specific training, and opinions regarding the role and competencies of the NM. Data were analyzed using descriptive methods.

Results. Among respondents, 73.4% reported being unaware of AI-based software for operating room flow management, while 52.1% considered the integration of such systems important for improving operational efficiency. A total of 83% expressed willingness to participate in specific AI training. The NM was

considered potentially useful for improving operating room management by 80.9% of respondents, while 84.1% indicated that this professional could facilitate the adoption of new technologies. Cultural resistance to change, limited resources, and insufficient training emerged as the main implementation barriers.

Discussion. The findings indicate substantial interest in technological innovation despite limited current familiarity with AI-based systems. Targeted education, organizational investment, and strengthened advanced nursing management competencies may support the sustainable integration of AI into Italian operating room workflows.

Keywords: Artificial Intelligence, Operating Rooms, Perioperative Nursing, Nursing Management, Nurse Managers, Workflow

Introduction

Operating room flow management encompasses the processes governing the surgical patient pathway, from the preoperative phase through discharge (Marzi & Torricelli, 2023; Guerriero & Guido, 2011). Its purpose is to balance operational efficiency and quality of care, with direct implications for patient safety, organizational well-being, and economic sustainability. The operating room complex is, in fact, an essential component of every hospital, significantly affecting costs, workload, and revenue (Pakhare et al., 2022).

Effective organization of staff roles and activities, together with clear and coordinated communication, can help reduce discomfort and work-related stress among healthcare personnel (Gruppo di lavoro ISS Salute mentale ed emergenza COVID-19, 2020). Experience gained during the COVID-19 pandemic also showed that robust infrastructure and well-defined procedures not only ensure staff safety but also help improve the resilience and overall efficiency of healthcare organizations (Fereidouni et al., 2023). Conversely, the lack of effective strategies tends to increase hospital costs, lengthen waiting lists, and compromise equity and access to care (WT Solutions, 2021; Getinge, 2019). In the current context, the adoption of artificial intelligence (AI)-based technologies is transforming scheduling and real-time monitoring, supporting safer and more efficient processes (Cosmai et al., 2024).

Operational and Logistical Management of the

Surgical Pathway

Appropriate management of the surgical pathway requires accurate planning, preparation, and logistical organization, including patient assessment, medical history review, and the coordination of personnel and materials (Marzi & Torricelli, 2023). Delays or errors at this stage may lead to unexpected reallocations, increasing the risk of inefficiencies. Galeazzi-Sant'Ambrogio represents an exemplary case, as the adoption of innovative technological solutions increased the punctuality of operating room admissions from 55% to 92% (WT Solutions, 2024). Furthermore, the absence of standardized protocols and adequate communication among surgical teams may worsen delays and scheduling overlaps, as highlighted in the guidelines of AOU Federico II of Naples (Azienda Ospedaliero Universitaria Federico II, 2022).

During surgical procedures, tools such as ORControl can improve turnover and reduce idle time between one operation and the next (Marzi & Torricelli, 2023; WT Solutions, 2021). At Galeazzi-Sant'Ambrogio, the implementation of these solutions increased operating room utilization from 60% to 90% (WT Solutions, 2024). A growing number of healthcare organizations also use AI and machine-learning algorithms to detect anomalies in real time (Ng et al., 2022), enabling timely corrective action and minimizing decision-making delays (WT Solution, 2021). This technology allows a prompt response to emergencies (Cosmai et al., 2024; Getinge, 2021), owing to its high dynamic adaptability, which makes the operating room system safer and

more responsive.

Postoperative patient management and discharge planning directly affect bed availability and the scheduling of new procedures. AI-based systems designed for continuous monitoring of vital signs allow early detection of complications (Ng et al., 2022). Moreover, effective discharge planning—as emphasized by Guerriero and Guido (2011)—reduces waiting lists and increases patient turnover, thereby optimizing overall resources.

The Role of AI in Surgical Pathway Management

AI plays a leading role throughout the surgical pathway, generating benefits ranging from cost containment to reduced waiting times. According to Sheth et al. (2022), AI-based preoperative planning software can minimize the number of surgical trays required and the associated sterilization costs. Furthermore, machine-learning models such as XGBoost and Random Forest (Bartek et al., 2019; Chu et al. 2022) provide more accurate predictions of procedure duration, supporting more rational operating room management.

AI can also predict the daily surgical demand (Riahi et al., 2023; Hassanzadeh et al., 2022) and coordinate the activities of downstream units such as recovery units and intensive care units (Eshghali et al., 2023). The use of Bluetooth Low Energy (BLE) devices (Bottani et al., 2023) improves patient tracking and the quality of the data collected, enabling even more accurate predictions (Bellini et al., 2024). AI-based monitoring of surgical instruments also helps reduce packaging errors (Zhu et al., 2019). The technologies described in the CADTH Horizon Scan (2024) likewise highlight the potential of AI to optimize patient flow, manage hospital resources, and accurately predict discharges and transfers, thereby improving the overall efficiency of hospital processes (Canadian Agency for Drugs and Technologies in Health, 2024).

From Predictive Analytics to IoT Solutions and Simulation

Predictive surgical scheduling, based on machine-learning algorithms, optimizes operating room allocation and reduces non-productive time (Hassanzadeh et al., 2022). Discrete-event simulation models allow multiple organizational scenarios to be evaluated,

highlighting their impact on operating room outcomes. Integration with the Internet of Things (IoT), particularly the use of real-time BLE devices, provides smoother intrahospital flows and continuous patient monitoring (Bottani et al., 2023).

Systems such as Torin enable continuous oversight of procedures and dynamic adjustments to surgical schedules (Getinge, 2021). At Klinikum Stuttgart, the introduction of Torin resulted in a 3.4% increase in the number of surgical procedures and a 4% increase in annual revenue (Getinge, 2019).

The Nurse Manager in Operating Room Management

Within this complex setting, the NM plays a pivotal role in implementing technological and managerial innovations in the operating room. This professional, equipped with advanced competencies in Operating Room Management, is responsible for:

- Interprofessional coordination: promoting effective communication among the different professional groups and integrating technologies into operational workflows (Gruppo di lavoro ISS Salute mentale ed emergenza COVID-19, 2020).
- Education and supervision: educating staff on the use of new technologies and ensuring their consistent and informed adoption. The second-level master's degree in Operating Room Management at Università Cattolica del Sacro Cuore focuses particularly on these aspects (Università Cattolica del Sacro Cuore, 2024).
- Performance monitoring: analyzing the main efficiency indicators, identifying critical issues, and implementing corrective strategies (Cosmai et al., 2024; Bellini et al., 2024).

Through coordinated action, the NM contributes significantly to the modernization of operating room procedures, promoting the adoption of AI technologies and improvements in the overall quality of care.

Based on the evidence that emerged—which emphasizes the growing relevance of AI, the importance of optimal operating room flow management, and the strategic value of the NM—it became necessary to examine the national

context in greater detail. In particular, it was considered a priority to assess both the actual adoption of AI technologies and the recognition and use of the NM in this field. To address this need, a descriptive study was initiated to provide an essential overview of the Italian situation regarding these aspects.

Methods

Study Design

The study was designed as a descriptive survey to explore the opinions and knowledge of Italian operating room nurses regarding the use of AI in operating room flow management and the role of the NM with advanced competencies.

Sample

The questionnaire was administered to 94 nurses working in 40 healthcare organizations across 13 Italian regions (Table 1). This sample included professionals from public and private organizations, with heterogeneous representation in terms of years of experience and work settings.

Data Collection Instrument

The data collection instrument was a structured questionnaire (Appendix 1), specifically designed to explore operating room nurses' opinions, knowledge, and perceptions regarding the use of artificial intelligence (AI) and the role of the Nurse Manager (NM) holding a second-level master's degree in "Operating Room Management".

The questionnaire was divided into three main sections and comprised 19 questions using a combination of formats: closed-ended questions; multiple-choice questions; Likert-scale questions to measure the degree of agreement or perception on a scale from 1 to 5; and open-ended questions, allowing participants to provide additional details or personal opinions.

Questionnaire Structure

The questionnaire is structured into three main sections.

Table 1. Names, cities, regions, and geographical areas of the healthcare organizations represented by the respondents.

Healthcare Organization	City	Region	Area
Fondazione IRCCS Policlinico San Matteo	Pavia	Lombardia	North
ASST Sette Laghi	Varese	Lombardia	North
Fondazione Poliambulanza	Brescia	Lombardia	North
ULSS 6 Euganea	Padova	Veneto	North
Istituto Europeo di Oncologia	Milano	Lombardia	North
ASST Ospedale Maggiore di Crema	Crema	Lombardia	North
Azienda Ospedaliera di Padova	Padova	Veneto	North
ASL Torino 5	Chieri	Piemonte	North
Azienda Ospedaliero-Universitaria di Ferrara	Ferrara	Emilia-Romagna	Nord
ASL Cuneo 1	Cuneo	Piemonte	Nord
ULSS 7 Pedemontana	Bassano del Grappa	Veneto	Nord
Azienda Ospedaliera di Alessandria	Alessandria	Piemonte	Nord
ASL 4 Chiavarese	Chiavari	Liguria	Nord
Azienda Sanitaria Universitaria Friuli Centrale	Udine	Friuli-Venezia Giulia	Nord
Istituto Giannina Gaslini	Genova	Liguria	Nord
Azienda Ospedaliera Universitaria Città della Salute e della Scienza	Torino	Piemonte	Nord
Policlinico Sant'Orsola-Malpighi	Bologna	Emilia-Romagna	Nord
Azienda USL di Bologna	Bologna	Emilia-Romagna	Nord
ASST Spedali Civili di Brescia	Brescia	Lombardia	Nord
Azienda Ospedaliero-Universitaria Pisana	Pisa	Toscana	Centre
ASL Lanciano Vasto Chieti	Chieti	Abruzzo	Centre
Fondazione Policlinico Universitario Agostino Gemelli	Roma	Lazio	Centre
Ospedale Pediatrico Bambino Gesù	Roma	Lazio	Centre
Clinica Villa Margherita	Roma	Lazio	Centre
IRCCS Istituti Fisioterapici Ospitalieri	Roma	Lazio	Centre
Università Campus Bio-Medico di Roma	Roma	Lazio	Centre
Azienda Ospedaliera Santa Maria di Terni	Terni	Umbria	Centre
Azienda Ospedaliera di Cosenza	Cosenza	Calabria	South
ASL Bari	Bari	Puglia	South
ASL Medio Campidano	Sanluri	Sardegna	South
ARNAS Civico	Palermo	Sicilia	South
IRCCS Fondazione Pascale	Napoli	Campania	South
Azienda Ospedaliera Pugliese Ciaccio	Catanzaro	Calabria	South
ASL Avellino	Avellino	Campania	South
Azienda Ospedaliera Universitaria Federico II	Napoli	Campania	South
AORN Santobono Pausilipon	Napoli	Campania	South
Salus Fisiokinesiterapia Service S.r.l.	Napoli	Campania	South
Azienda Ospedaliera dei Colli	Napoli	Campania	South

The first section, devoted to work experience, collects basic information about participants, including years of service in the operating room, type of employing organization (public or private), and operational setting (operating room department, single-specialty operating room, or multispecialty operating room). It also investigates participants' perceptions of the impact of surgical list management on daily work and the organizational climate using a Likert scale.

The second section examines knowledge and perceptions of AI. In particular, it assesses familiarity with software such as Torin and ORControl, distinguishing among active use, awareness without use, and complete lack of familiarity. It examines the perceived importance of AI for improving operational efficiency, reducing workload, and facilitating communication among team members, as well as willingness to participate in specific training programs. The section also explores the main barriers to AI implementation, such as resistance to change, lack of resources, or technical complexity, and the possible impact of AI on professional responsibilities.

The third section focuses on the NM role, investigating participants' level of awareness of this professional role and its presence in their organizations. It also explores the perceived usefulness of the NM in optimizing operating room flow management and adopting AI technologies. Finally, it collects opinions on the essential competencies of an NM, including data analysis, operational flow management, leadership, and staff education.

Methods of Analysis

The data collected were analyzed using descriptive methods:

- Calculation of frequencies and percentages for each closed-ended question.
- Thematic analysis of open-ended responses to identify common trends and relevant opinions.

This analysis provided an overview of nurses' knowledge and perceptions, highlighting significant trends and barriers to the implementation of AI and the NM role in Italian operating rooms.

Results

The sample (n=94) included professionals from public and private organizations (75% vs 24.5%), with heterogeneous representation in terms of both years of experience (less than 1 year, 16%; 1–5 years, 40.4%; 6–10 years, 20.2%; more than 10 years, 23.4%) and work settings (operating room department, 51.1%; multispecialty operating room, 19.1%; single-specialty operating room, 29.8%).

Relevance of the Issue

On a Likert scale from 1 (not at all) to 5 (very much), 89.4% selected 4 or 5 in response to the question concerning whether operating room flow management is a determining factor in the department's organizational climate (Figure 1). When asked how much it affects their daily work, 75.5% of respondents selected a score of 4 or 5.

Ritieni che la gestione del flusso operatorio influisca sul clima organizzativo?

94 risposte

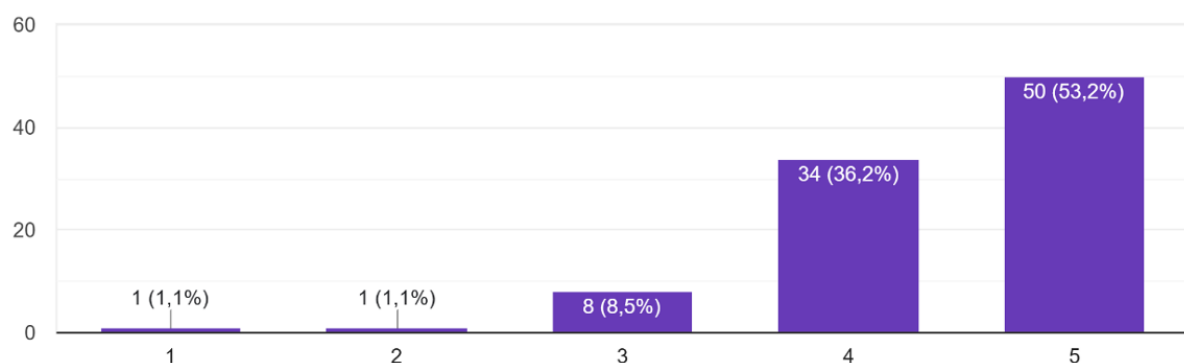


Figure 1. Perceived influence of operating room flow management on the organizational climate. Participants were asked: "Do you think that operating room flow management affects the organizational climate?"

Knowledge of AI, Opinions, and Confidence Levels

Among the Italian operating room nurses surveyed, 73.4% reported that they were unaware of AI software for operating room flow management (Figure 2). However, 52.1% recognized the importance of integrating such systems to improve operational efficiency (Figure 3). High confidence levels, corresponding to responses of 4 or 5 on a 1-to-5 Likert scale, were expressed regarding the ability of AI systems to reduce workload and work-related stress and to improve communication and coordination among members of the surgical team, by 57.5% and 51.1% of respondents, respectively. A score of 1 or 2 for both questions was assigned by fewer than 21% of the surveyed sample. Regarding confidence that AI implementation could improve patient safety, 82.6% assigned a score from 3 to 5 (3: 33.7%; 4: 35.9%; 5: 13%). Finally, the most frequently selected responses to the question “How do you think the introduction of AI could change your role in the operating room?” were increasing process supervision and monitoring (52.1%) and requiring new technological competencies (29.8%).

Role of the Nurse Manager

A total of 56.4% of the sample reported being unfamiliar with the role of an NM holding a second-level master's degree in Operating Room Management. Consistent with this finding, only

Sei a conoscenza di piattaforme o software di gestione del flusso operatorio basati su IA, come Torin?
94 risposte

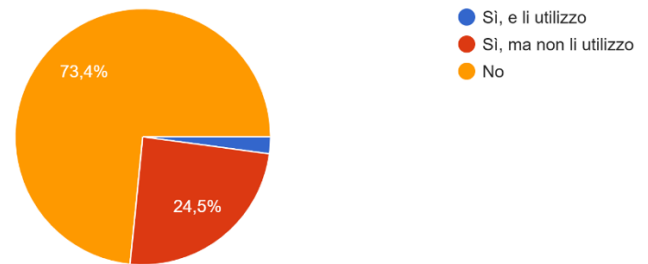


Figure 2. Awareness and use of AI-based operating room flow management platforms or software. Participants were asked: “Are you aware of AI-based operating room flow management platforms or software, such as Torin?”

3.2% of respondents reported the presence of an NM in their organization, whereas 85.1% answered negatively (Figure 4). As shown in Figure 5, 80.9% of respondents assigned a score from 3 to 5 to the question concerning the usefulness of the NM in improving operating room management. Similarly, 84.1% expressed a level of agreement from 3 to 5 that this professional could facilitate the adoption of new technologies in the operating room. Finally, the most frequently selected responses to the question “What specific competencies do you think a nurse with a master's degree in Operating Room Management should possess to support AI implementation?” were data analysis skills and use of advanced software (42.9%), leadership and coordination skills (31.9%), and operational flow management (12.1%).

Pensi che l'introduzione di un software basato su IA per la gestione del flusso operatorio sia importante per il miglioramento dell'efficienza?

94 risposte

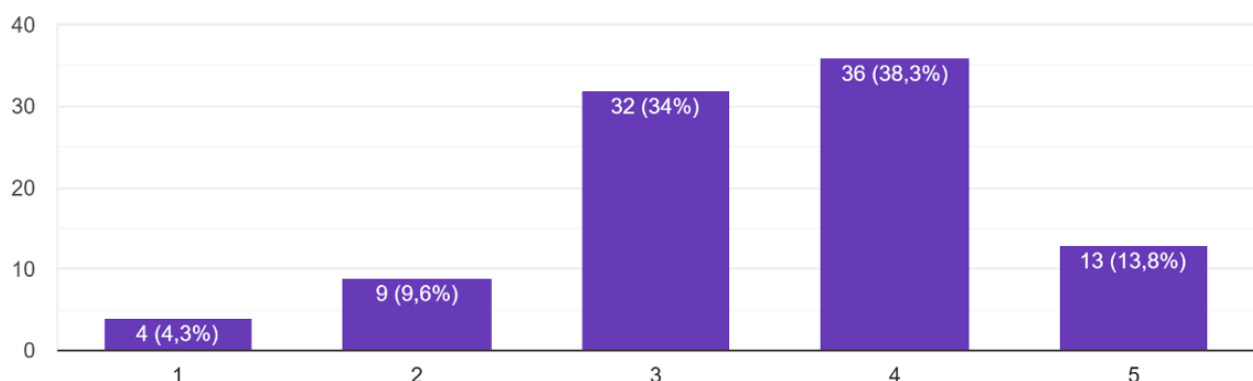


Figure 3. Perceived importance of AI-based software for improving operating room efficiency. Participants were asked: “Do you think that introducing AI-based software for operating room flow management is important for improving efficiency?”

Questa figura professionale esiste nella tua realtà lavorativa?
94 risposte

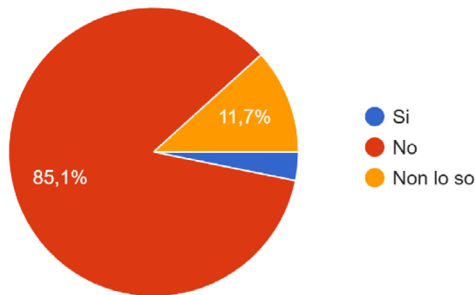


Figure 4. Presence of the Nurse Manager role in respondents' workplaces. Participants were asked: "Is this professional role present in your workplace?"

Identified Challenges

The main barriers identified in implementing AI software in respondents' workplaces were cultural resistance to change (44.7%), lack of resources or funding (23.4%), and insufficient specific training (17%) (Figure 6).

Willingness to Undertake Training

A total of 83% of nurses reported being willing to participate in specific training programs on the use of AI in the operating room (Figure 7).

Quali potenziali sfide o ostacoli vedi nell'implementazione di software basati su IA nella tua realtà lavorativa?
94 risposte

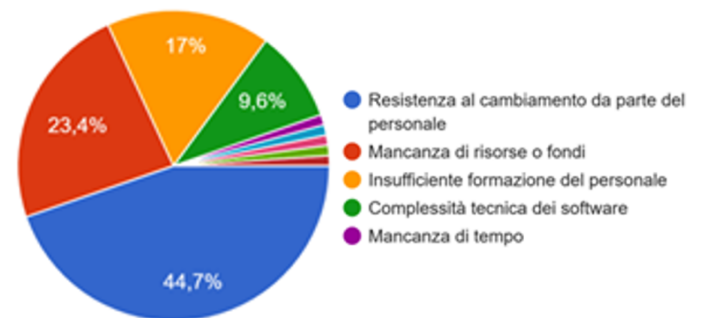


Figure 6. Perceived barriers to the implementation of AI-based software in respondents' workplaces. Participants were asked: "What potential challenges or barriers do you see in implementing AI-based software in your workplace?"

Ritieni che l'implementazione della figura dell'infermiere con master di II livello in "Operating Room Management" potrebbe essere utile per migliorare la gestione della sala operatoria?

94 risposte

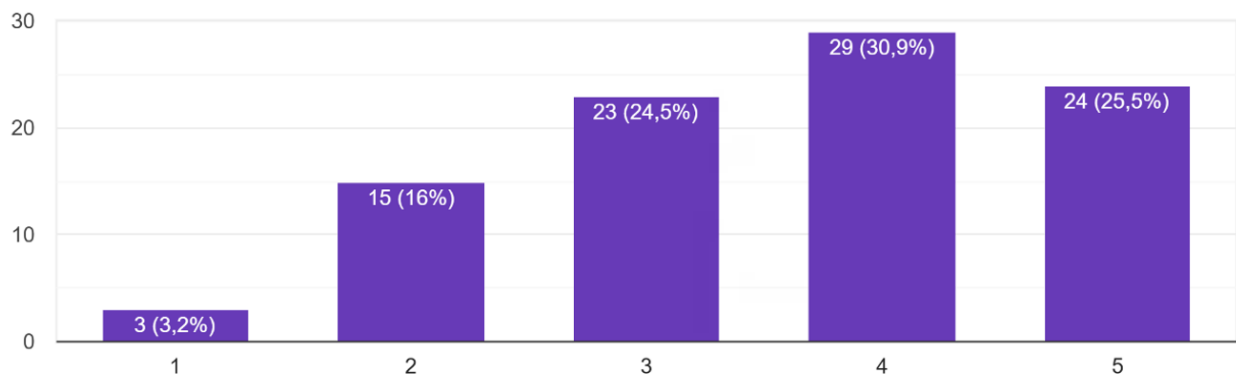


Figure 5. Perceived usefulness of a Nurse Manager with advanced training in Operating Room Management. Participants were asked: "Do you think that introducing the role of a nurse holding a second-level master's degree in 'Operating Room Management' could be useful for improving operating room management?"

Saresti disposto/a a partecipare a un training specifico per l'implementazione e l'utilizzo di un software basato su IA?

94 risposte

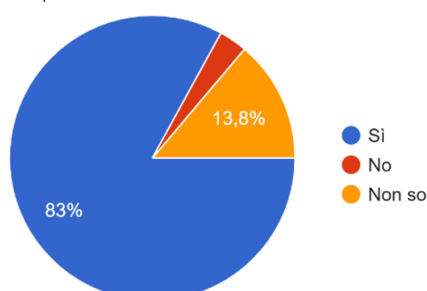


Figure 7. Willingness to participate in specific training on AI-based software. Participants were asked: "Would you be willing to participate in specific training on the implementation and use of AI-based software?"

Ethical Considerations

The study involved adult healthcare professionals who voluntarily completed an anonymous survey. Before participation, respondents received an information statement explaining the study objectives, the voluntary nature of participation, data confidentiality, and data processing procedures. The study did not involve patients, clinical interventions, or the collection of directly identifiable personal or health data. All data were analyzed and reported exclusively in aggregate form. Completion and submission of the questionnaire after reading the participant information statement were considered to constitute informed consent to participate. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Discussion

This multi-organizational descriptive study provides a snapshot of operating room nurses' perceptions of operating room flow management, artificial intelligence (AI), and the potential contribution of the Nurse Manager (NM) with advanced competencies in Operating Room Management. Three findings appear particularly relevant. First, operating room flow was perceived as having a substantial influence on both daily work and the organizational climate. Second, familiarity with AI-based operating room management technologies was limited, despite generally favorable expectations regarding their potential usefulness and a high willingness to undertake specific training. Third, the specialized NM role investigated in this study was rarely reported within respondents' organizations, although participants generally perceived advanced managerial and technological competencies as potentially useful for supporting operating room organization and technological innovation.

The perceived importance of operating room flow is consistent with the broader literature showing that operating room performance depends not only on technical or surgical variables but also on organizational factors, scheduling, communication, resource coordination, and team functioning. Systematic evidence indicates that operating room organization can influence surgical performance

and that organizational interventions may affect efficiency, safety, and quality-related outcomes (Pasquer et al., 2024). Similarly, audits of operating room utilization have identified delayed starts, cancellations, communication problems, and suboptimal resource planning as important sources of inefficiency (Pakhare et al., 2022). The present findings therefore reinforce the concept of operating room flow as a sociotechnical process in which scheduling, human resources, communication, technology, and clinical activities are closely interconnected rather than independent components.

An important finding is the apparent discrepancy between limited familiarity with AI technologies and openness toward their adoption. In this sample, 73.4% of respondents reported that they were unaware of AI-based software for operating room flow management, yet 52.1% rated the importance of introducing such systems for operational efficiency as 4 or 5 on a five-point scale, and 83% expressed willingness to participate in specific training. This pattern may reflect an implementation-readiness gap: nurses may recognize the potential relevance of AI while having limited direct exposure to the technologies currently available. Similar findings have been reported in nursing populations, where interest in AI frequently coexists with limited knowledge, experience, or formal education regarding its clinical application (Abuzaid et al., 2022; Alruwaili et al., 2024; Tuncer & Tuncer, 2024). Consequently, favorable attitudes toward innovation should not be considered equivalent to technological preparedness; rather, they identify an opportunity for structured professional development.

The expectations expressed by participants are also consistent with the growing literature on AI-supported operating room management. Machine-learning models have demonstrated the ability to improve predictions of surgical case duration and operating room utilization compared with conventional estimates, potentially supporting more accurate scheduling and resource allocation (Bartek et al., 2019; Chu et al., 2022; Riahi et al., 2023). Other models have been developed to forecast daily surgical demand or integrate elective and emergency scheduling, further illustrating the potential of predictive analytics in complex operating environments (Eshghali et al., 2024; Hassanzadeh et al., 2022). A systematic review

specifically examining AI in operating room management identified applications involving surgical duration prediction, scheduling, resource allocation, cancellation prediction, and perioperative capacity management (Bellini et al., 2024). Taken together, these studies support the plausibility of the benefits perceived by respondents; however, much of the available evidence concerns predictive performance and optimization models rather than prospective demonstration of improved patient, workforce, or organizational outcomes. AI should therefore be viewed as a decision-support resource rather than as a replacement for professional and managerial judgment.

This distinction is particularly important when interpreting the perceived effects of AI on workload, communication, and patient safety. In the present study, 57.5% of respondents expressed high confidence that AI could reduce workload and work-related stress, and 51.1% expressed high confidence that it could improve communication and coordination. Similarly, 82.6% assigned a score between 3 and 5 regarding AI and patient safety. These results describe expectations rather than measured effects. Reviews of AI applications in nursing have identified potentially beneficial uses in monitoring, prediction, decision support, documentation, and organizational processes, while also emphasizing heterogeneity in technologies and outcome measures and the continuing need for robust clinical evaluation (Cosmai et al., 2024; Ng et al., 2022). Therefore, future implementation studies should assess whether technological adoption actually produces measurable improvements in workload, communication, safety, and workflow rather than assuming that technical performance necessarily translates into better clinical or organizational outcomes.

The findings concerning the NM are particularly relevant from an organizational perspective. Only 3.2% of respondents reported the presence of the specialized professional role described in the questionnaire, while more than half were unfamiliar with it. Nevertheless, respondents attributed considerable potential value to competencies such as data analysis and advanced software use, leadership and coordination, and operational flow management. This profile is consistent with emerging evidence concerning the role of nurse managers in digitally transformed

healthcare environments. A recent systematic review found that AI-supported technologies may contribute to nursing management through resource optimization, decision support, risk assessment, communication, and administrative processes, while emphasizing the importance of training and interdisciplinary collaboration for successful implementation (Gonzalez-Garcia et al., 2024). Nurse managers have also been identified as important actors in creating organizational conditions in which AI can be introduced responsibly and integrated into existing clinical workflows (Peltonen & Topaz, 2022).

At the same time, these results require cautious interpretation. The finding that 80.9% of respondents selected scores from 3 to 5 regarding the usefulness of the NM includes the midpoint of the scale and should therefore be interpreted as a neutral-to-positive distribution, rather than as evidence that approximately 81% unequivocally considered the role essential. The same caution applies to the 84.1% who selected scores from 3 to 5 regarding the NM as a facilitator of technological adoption. Furthermore, the present study investigated a specific professional profile associated with postgraduate education in Operating Room Management. Existing literature supports the broader importance of nursing leadership, digital competencies, and change management, but does not establish that one specific postgraduate qualification is necessary or sufficient to produce these outcomes. The present findings should therefore be interpreted as supporting the potential value of advanced managerial competencies rather than demonstrating the effectiveness of a particular professional credential.

The barriers identified by respondents further emphasize that AI implementation is primarily an organizational change process rather than a purely technological one. Cultural resistance to change was the most frequently reported barrier (44.7%), followed by lack of resources or funding (23.4%) and insufficient specific training (17%). This finding is consistent with implementation research in the operating room. Smith et al. (2022), in developing a change-management model for AI-enabled technologies in surgical environments, highlighted early stakeholder engagement, multidisciplinary team involvement, adaptation to institutional culture, continuous communication, and

anticipation of organizational and regulatory barriers as central elements of implementation. Similarly, the nurse-management literature identifies resistance to technological change, inadequate competencies, and ethical and organizational concerns among the principal challenges to AI adoption (Gonzalez-Garcia et al., 2024). Technology alone is therefore unlikely to improve operating room flow if existing workflows, professional responsibilities, communication pathways, and organizational culture are not addressed simultaneously.

The high willingness to undertake training observed in this study represents an important opportunity. Evidence from educational interventions suggests that structured AI education can increase nurses' knowledge and understanding of AI technologies, although improvement in knowledge does not automatically produce equivalent changes in attitudes or adoption behavior (Karaarslan et al., 2024). Training for operating room professionals should consequently extend beyond basic software instruction and include data literacy, interpretation of algorithmic outputs, recognition of model limitations, workflow redesign, cybersecurity and data protection principles, ethical considerations, and human oversight. International guidance similarly emphasizes transparency, accountability, human autonomy, safety, and appropriate governance when AI is introduced into healthcare systems (World Health Organization, 2021).

From an implementation perspective, these findings support a gradual rather than technology-driven approach to AI adoption. Healthcare organizations could initially identify specific workflow problems, establish baseline performance indicators, and introduce AI-supported solutions through controlled pilot projects. Relevant outcomes could include first-case on-time starts, operating room utilization, turnover time, overtime, cancellations, scheduling accuracy, recovery-unit bottlenecks, staff workload, user acceptance, and patient-safety indicators. The NM or another appropriately trained perioperative leader could contribute by linking clinical staff, hospital management, information technology teams, and technology providers; however, the effectiveness of such a model should itself be prospectively evaluated rather than assumed.

Several limitations should be considered when interpreting the findings. The sample was relatively small and, although respondents represented 40 healthcare organizations across 13 Italian regions, it cannot be considered representative of all Italian operating room nurses. The descriptive and cross-sectional design precludes causal inference and does not permit identification of factors independently associated with attitudes toward AI or the NM role. The study relied on self-reported perceptions rather than objective measures of AI adoption, operating room efficiency, workload, or patient outcomes. In addition, the study-specific questionnaire does not report psychometric validation, which may limit the reliability and construct validity of some measures. The questionnaire also referred collectively to "AI-based" platforms and software, although contemporary operating room technologies may combine workflow control, real-time tracking, predictive analytics, and AI functions; respondents may therefore have interpreted the concept of AI differently. Finally, interpretation of Likert-scale findings should distinguish neutral midpoint responses from clearly positive responses. Future studies should use validated instruments where possible, larger probabilistic or systematically recruited samples, inferential analyses, and prospective implementation designs to determine whether AI-supported operating room management and advanced nursing leadership roles translate into measurable organizational, workforce, and patient outcomes.

Study Limitations

The study has several limitations, including the sample size and the absence of inferential statistical analysis. Furthermore, although the geographical representation was substantial, it may not reflect the entire national context.

Conclusions

This study showed that ineffective operating room flow management is perceived by nurses as a major critical issue, with consequences for the organizational climate and operational efficiency. Although the use of AI remains limited (73.4% of respondents reported being unfamiliar with its application), strong interest

in its adoption emerged, supported by broad willingness to undertake specific training (83%). Although the Nurse Manager role was poorly represented (only 3.2% of respondents reported its presence), it was recognized as essential for facilitating AI integration and promoting organizational change (84.1% believed that this professional could act as a facilitator).

The main barriers identified, such as cultural resistance to change (44.7%) and the lack of financial and educational resources (40.4%), require targeted interventions. The adoption of an integrated approach that enhances the NM role and promotes technological innovation represents a decisive step toward more efficient and sustainable operating room flow management.

Looking ahead, this study provides a basis for further research aimed at exploring organizational dynamics, measuring the impact of AI, and developing strategies to promote its adoption. The synergy between technology and advanced competencies is confirmed as a crucial lever for ensuring sustainability and innovation in Italian healthcare systems.

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Intraoperative Awareness: Comparison Between Total Intravenous Anesthesia (TIVA) and Balanced Anesthesia: A Prospective Observational Study

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Conflict of Interest: The authors declare no conflict of interest.

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Abstract

Introduction. Intraoperative awareness is a rare but clinically significant complication of general anesthesia characterized by the recovery of consciousness, with or without explicit recall, during surgery. Although its incidence is generally low, awareness may result in relevant psychological consequences, including anxiety, intrusive memories, sleep disturbances, and post-traumatic stress disorder. The risk may vary according to anesthetic technique and the adequacy of anesthetic depth monitoring. This study aimed to assess the occurrence of intraoperative awareness among patients undergoing general anesthesia and to describe its occurrence according to the use of total intravenous anesthesia (TIVA) or balanced anesthesia.

Methods. A prospective observational study was conducted among 100 adult patients undergoing endocrine surgery under general anesthesia. Data were collected at two time points. During the intraoperative phase (T0), clinical characteristics, anesthetic technique, monitoring modalities, and signs potentially suggestive of awareness were recorded. One hour after emergence from anesthesia (T1), patients completed the Modified Brice Questionnaire to identify memories, dreams, or perceptions related to the intraoperative period.

Results. Of the 100 patients included, 76 underwent TIVA and 24 received balanced anesthesia. One case of intraoperative awareness was identified, corresponding to an overall

incidence of 1%. The episode occurred during TIVA and was associated with intraoperative involuntary movements and increased heart rate. Postoperative assessment confirmed recollection compatible with awareness. Most participants reported no intraoperative memories or unusual perceptions. **Discussion.** Intraoperative awareness was uncommon in this sample but occurred during TIVA. These findings support careful assessment of anesthetic depth and the use of appropriate monitoring strategies, particularly during total intravenous anesthesia. Standardized protocols and continuous clinical surveillance remain important components of perioperative patient safety.

Keywords: Intraoperative Awareness, General Anesthesia, Total Intravenous Anesthesia, Balanced Anesthesia, Anesthetic Depth Monitoring, Patient Safety

Introduction

General anesthesia represents one of the most significant tools of modern medicine, enabling the performance of complex surgical procedures through the pharmacological induction of a reversible state of unconsciousness, amnesia, analgesia, and muscle relaxation. Despite advances in pharmacological agents and monitoring techniques, the management of anesthetic depth remains a critical challenge, as inadequate anesthesia may lead to significant clinical risks, including the phenomenon of intraoperative awareness.

Intraoperative awareness is a rare but clinically significant phenomenon, characterized by a patient's consciousness during surgery under general anesthesia, with the possibility of recalling intraoperative events either explicitly or implicitly (Ghoneim, 2009). Although its incidence in the general population is low, estimated at approximately 0.1–0.2% of cases (Sebel et al., 2004), intraoperative awareness can have substantial emotional and psychological consequences, including anxiety, sleep disturbances, depression, and, in more severe cases, the development of post-traumatic stress disorder (PTSD) (Leslie et al., 2010). The severity of these effects depends on factors such as the presence of pain, paralysis, or a perceived sense of helplessness during the procedure, as well as the patient's ability to recall the intraoperative experience in detail (Sandin et al., 2000).

The risk of intraoperative awareness may vary

depending on several factors, including patient clinical characteristics, the type of surgical procedure, and, in particular, the anesthetic technique used (Ghoneim, 2009). Among the main modalities of general anesthesia, this study aimed to analyze and compare Total Intravenous Anesthesia (TIVA) and balanced inhalational anesthesia. As reported in the literature, the TIVA technique, based on the continuous administration of intravenous anesthetics such as propofol, may make the assessment of anesthetic depth more challenging (Avidan et al., 2011), whereas balanced anesthesia allows for more direct monitoring through clinical parameters and the measurement of minimum alveolar concentration (MAC) (Myles & Leslie, 2017).

The possibility that the anesthetic technique may influence the occurrence of intraoperative awareness has led the scientific community to investigate the comparison between TIVA and balanced anesthesia. In recent years, numerous studies and literature reviews have examined whether one of these approaches may be more effective in reducing the risk of intraoperative awareness (Mashour et al., 2012; Pandit et al., 2014). The aim of this study is to observe the incidence of intraoperative awareness in patients undergoing general anesthesia.

Methods

Study Design and Setting

This study compares two different anesthetic

techniques, Total Intravenous Anesthesia (TIVA) and balanced anesthesia, in order to evaluate whether the method employed may influence the risk of intraoperative awareness. Episodes were recorded using standardized tools, and the results were analyzed in relation to the available scientific evidence.

To address the research question, a prospective observational study was conducted.

The study was conducted at the Azienda Ospedaliero-Universitaria Pisana (AOUP), in the Endocrine Surgery Operating Unit, a highly specialized setting for the management of patients undergoing endocrine surgery, between July and September 2025.

Ethical Considerations

The study was conducted following authorization from the Director of the Endocrine Surgery Unit and the Department of Nursing Professions of AOUP, in accordance with the study protocol, Version 1.0 dated October 17, 2024, which was approved according to the procedures established by the relevant Ethics Committee.

Data processing was performed in full compliance with Italian Legislative Decree No. 196/2003 and Regulation (EU) No. 679/2016 on personal data protection. Participants were free to withdraw from the study at any time without any consequences.

Data Collection Instruments

Data collection was carried out using two distinct instruments, subsequently integrated into a single structured and comprehensive observational form (see Appendix 1):

1. Intraoperative observational form (T0), specifically designed and developed by the researcher for this study and completed during surgery. It allowed the recording of demographic data (age, sex), clinical data (type and duration of surgery), anesthesiological data (drugs administered, technique used, intraoperative parameters), and the presence of any variations or complications (see Appendix 1).
2. Modified Brice Questionnaire (T1), used

to detect any episodes of intraoperative awareness in the postoperative period.

The Intraoperative observational form was specifically developed to systematically monitor the phenomenon of intraoperative awareness. The tool was designed to ensure accurate and standardized recording of relevant clinical and care-related variables, with the aim of identifying any episodes of intraoperative awareness during surgery.

The form is structured into four main sections, allowing for comprehensive data collection throughout the entire perioperative pathway:

- The first three sections of the observational form are completed by the researcher at Time Zero (T0), corresponding to the intraoperative phase, and include:
 1. Patient profile: includes essential demographic and clinical data (age, sex, BMI, type of surgery, ASA score, and comorbidities), as well as any ongoing pharmacological therapies that may interfere with the anesthetic response.
 2. Anesthesiological conditions: collects information regarding the type of anesthesia administered (TIVA or balanced anesthesia), drugs used during premedication and induction, duration of anesthesia, and type of monitoring applied, with particular reference to the presence or absence of BIS monitoring.
 3. Intraoperative awareness episode: documents the possible occurrence of physiological or behavioral signs suggestive of intraoperative awareness (changes in heart rate or blood pressure, involuntary movements, respiratory alterations, or increased EtCO₂), indicating the timing and duration of the episode.
- The fourth section is completed at Time One (T1), one hour after emergence from general anesthesia, and includes:
 4. Modified Brice Questionnaire (Brice et al., 1970), used to explore the presence of memories, dreams, or perceptions during the intraoperative phase.

The Modified Brice Questionnaire is a validated and widely used tool in the literature, derived from the original questionnaire proposed by Brice et al. (1970) and subsequently modified to increase its sensitivity (Mashour

et al., 2013; Tasbihgou et al., 2018). The questionnaire consists of targeted open-ended questions, including (see Appendix 1):

- What is the last thing you remember before going to sleep?
- What is the first thing you remember after waking up?
- Do you remember anything between going to sleep and waking up?
- Did you dream during your procedure?
- Were your dreams disturbing to you?

Numerous studies have shown that the use of the Modified Brice Questionnaire allows the identification of a significantly higher number of awareness episodes compared to spontaneous patient reports (Mashour et al., 2013; Pandit et al., 2014). Furthermore, early and repeated administration reduces the risk of underestimation, as some patients report delayed memories only hours or days after surgery (Samuelsson et al., 2007).

In the present study, the Modified Brice Questionnaire was administered 1 hour after awakening in the Recovery Room (T1), in order to promptly detect any episodes of intraoperative awareness. This timing allowed the evaluation of patients' perceptions and memories in a very early postoperative phase, within a protected and controlled environment, ensuring maximum accuracy in data collection.

The integration of objective data collected at T0 and subjective data obtained at T1 allows for the construction of a comprehensive and accurate clinical picture, useful for assessing the incidence of intraoperative awareness and comparing the results with the evidence reported in the scientific literature.

Data Collection Methods

Data were collected at two different time points:

Time Zero (T0): Intraoperative Phase

During the intraoperative phase, the researcher completed the first three sections of the observational form, recording patient clinical data, the anesthetic technique used, vital parameters, and any occurrence of signs compatible with possible intraoperative awareness.

Time One (T1): 1 Hour Postoperative

Corresponding to one hour after emergence from general anesthesia. In the Recovery Room, the Modified Brice Questionnaire (Brice et al., 1970) was administered to investigate the presence of any memories, dreams, or perceptions related to the intraoperative phase.

Eligibility Criteria

Inclusion criteria. Adult patients aged between 18 and 70 years undergoing endocrine surgery in the endocrine surgery operating rooms, under general anesthesia performed using either TIVA or balanced anesthesia.

Exclusion criteria. Patients undergoing local or regional anesthesia without general sedation, or patients unable to complete the postoperative questionnaire due to their clinical conditions.

Results

A total of 100 patients were included in the study, of whom 56 were female (56%) and 44 were male (44%), with a mean age of 45 years. The most frequent surgical procedures were total thyroidectomy (53%), followed by partial thyroidectomy (29%), parathyroidectomy (15%), and lateral neck dissection (3%). The mean durations of the procedures were 75, 40, 50, and 125 minutes, respectively. These data, summarized in Table 1, describe a clinically heterogeneous yet representative sample of the institution's surgical activity.

Alongside demographic and surgical data, major pre-existing conditions and ongoing therapies were recorded, including cardiovascular, metabolic, respiratory, and neurological disorders, as well as the use of medications potentially interfering with the anesthetic response (e.g., beta-blockers, antihypertensives, antiepileptics, antidepressants, benzodiazepines).

The systematic collection of these variables, reported in Table 2, was essential to identify potential predisposing factors that, according to the literature, may influence sensitivity to anesthetic agents or increase vulnerability to intraoperative awareness (Ghoneim, 2009; Myles & Leslie, 2017).

Table 1. Patient characteristics.

Clinical Indicators	Data	%
Mean Age	45 years	
18–35 years	17	17%
35–50 years	48	48%
>50 years	35	35%
Sex		
Male	44	44%
Female	56	56%
Type of surgery		
Total Thyroidectomy	53	53%
Partial Thyroidectomy	29	29%
Parathyroidectomy	15	15%
Lateral neck dissection	3	3%
Mean BMI	28	
Severe underweight	0	0%
Underweight	0	0%
Normal weight	36	36%
Overweight	48	48%
Class I obesity	10	10%
Class II obesity	2	2%
Class III obesity	4	4%
ASA score		
I	12	12%
II	72	72%
III	16	16%

Table 2. Pre-existing conditions and ongoing pharmacological therapies.

Clinical Indicators	Data	%
Pre-existing conditions		
Cardiovascular diseases	12	12%
Metabolic diseases	5	5%
Renal diseases	1	1%
Respiratory diseases	0	0%
Neurological diseases	3	3%
None	79	79%
Pharmacological Therapy		
None	88	88%
Benzodiazepines	2	2%
Beta-blockers	9	9%
Opioids	0	0%
Antidepressants	1	1%
Antiepileptic	0	0%

During the intraoperative phase at Time Zero (T0), patients were classified according to the anesthetic technique used, as shown in Figure 1: 76 subjects (76%) underwent TIVA, while 24 (24%) received balanced anesthesia.

This distribution allowed for a direct

comparison between two techniques known to differ significantly in terms of anesthetic depth monitoring. Indeed, several studies report that TIVA, although a safe and widely used technique, is more sensitive to unintentional variations in the hypnotic level, particularly in the absence of dedicated monitoring tools such as BIS or Entropy (Avidan et al., 2011; Mashour et al., 2012). Our findings are consistent with these observations.

TYPE OF GENERAL ANESTHESIA

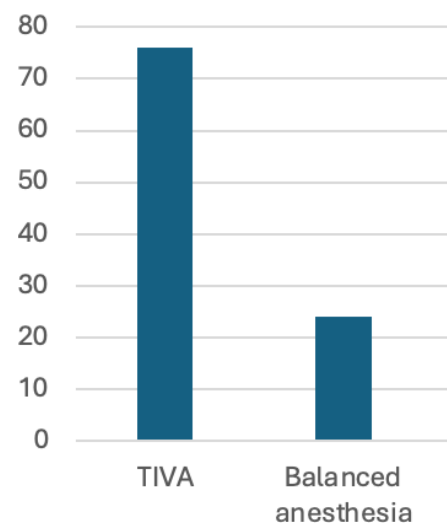


Figure 1. Type of general anesthesia administered to patients.

Table 3. Occurrence of intraoperative awareness in the study population.

Intraoperative Awareness	Data	n (%)
Yes	1	1%
No	99	99%

During the entire observation period, intraoperative awareness was identified in only one patient (1%), as reported in Table 3. The episode occurred during a partial thyroidectomy performed under TIVA and manifested during the maintenance phase of anesthesia (T2). Intraoperative data documented the occurrence of involuntary movements and an increase in heart rate, both indicators consistent with a possible partial return of consciousness. According to the literature, many awareness episodes occur during transitional phases of anesthesia, particularly during maintenance when titration is not adequately stable or properly monitored

(Sebel et al., 2004; Ghoneim, 2009).

The observed incidence (1%) is slightly higher than that reported in most international studies (0.1–0.2%), but it falls within the range described in analyses conducted in settings with heterogeneous protocols or limited sample sizes, such as the study by Xu et al. (2009), which reports incidences of up to 0.41%. Considering the observational nature of the study and the relatively small sample size, this difference should not be interpreted as an anomaly, but rather as confirmation of the variability of the phenomenon and the need to investigate it even through smaller samples.

One hour after emergence, at Time One (T1), all patients were administered the Modified Brice Questionnaire, a tool considered the gold standard for the retrospective detection of awareness (Brice et al., 1970). Analysis of the responses, summarized in Figure 2, showed that the majority of subjects did not recall anything from the intraoperative phase. Only 9% of participants reported dreaming, and only one patient (1%) described an unpleasant or distressing dream. The single confirmed case of awareness was fully consistent with what had been observed at T0, thereby reinforcing the validity of the assessment.

Percentage distribution of responses to the Modified Brice Questionnaire

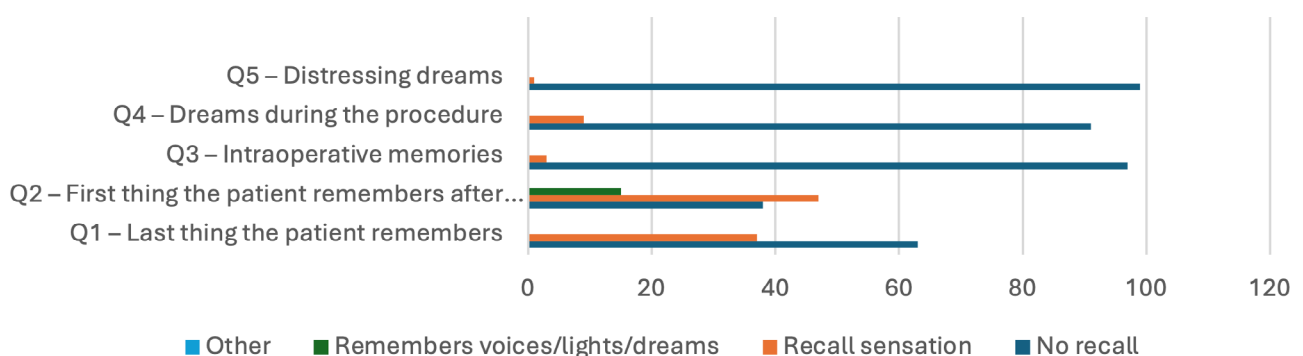


Figure 2. Overall distribution of responses to the modified brice questionnaire (T1).

Discussion

Overall, the results obtained are largely consistent with the available scientific evidence and reaffirm some key principles of anesthetic practice. First, intraoperative awareness, although a rare phenomenon, represents a clinically significant event due to the potential severity of its psychological consequences, which may include anxiety, intrusive memories, and in more severe cases, post-traumatic stress disorder (Ghoneim, 2009; Mashour et al., 2012).

Second, the increased vulnerability associated with TIVA highlighted by the single case observed in this study is fully consistent with findings reported in numerous international analyses, which recommend the systematic

use of depth of anesthesia monitoring in total intravenous techniques (Avidan et al., 2011; Myles & Leslie, 2017).

Finally, the results emphasize the importance of a multimodal anesthetic approach based on the combination of continuous monitoring, standardized protocols, and adequate training of healthcare personnel. Even in the presence of a single episode, awareness is a sensitive indicator of the quality and safety of care and highlights the need to maintain high standards of clinical vigilance throughout all phases of general anesthesia.

Conclusions

This study confirms that intraoperative awareness is a rare but clinically and

psychologically significant phenomenon, with an observed incidence (1%) consistent with the variability reported in the international literature. Even a single episode may result in relevant consequences for patient well-being, including anxiety, intrusive memories, or, in more severe cases, post-traumatic stress disorder. For this reason, the prevention of awareness represents a primary objective in anesthetic safety.

An initial consideration concerns the limitations of the study, particularly the small sample size and the relative homogeneity of the surgical procedures analyzed. Future studies should include a larger and more diverse sample in order to achieve greater statistical robustness and a more accurate characterization of risk factors associated with different anesthetic techniques.

The results also highlight the crucial role of anesthetic depth monitoring. The systematic use of dedicated tools, such as BIS or Entropy, appears to be essential, especially in total intravenous techniques, where the absence of objective parameters such as MAC makes the control of the hypnotic level more challenging. The adoption of standardized and shared protocols, together with continuous training of the anesthesiology team, represents an additional key element in reducing the risk of awareness episodes.

In addition to technical aspects, this phenomenon also raises a central ethical dimension: the protection of patient dignity, trust, and psychological integrity. Every episode of intraoperative awareness, even if isolated, should be considered an opportunity for learning and continuous improvement for the professionals involved.

This study reiterates the need to continue exploring and understanding intraoperative awareness as an integral part of the continuous improvement process in anesthetic practice. It is not only a matter of identifying the clinical or pharmacological causes underlying this phenomenon, but also of recognizing that behind every possible episode of awareness there is a person, with their vulnerability, fears, and trust in healthcare professionals. For this reason, every experience of awareness, even if isolated, should be considered an opportunity for learning and professional growth for the entire surgical team. Studying these events

contributes to the advancement of anesthetic safety while also promoting a culture of care centered on prevention, attentiveness, and professional awareness.

In conclusion, intraoperative awareness is not merely a potential clinical issue, but a phenomenon that strongly calls attention to the ethical and human dimension of care. Preventing this phenomenon means not only avoiding a clinical risk, but also safeguarding patient dignity, trust, and psychological integrity, ensuring that the surgical experience remains safe in all its aspects.

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Observational Study on the Appropriate Use of Personal Protective Equipment During the COVID-19 Pandemic: An Italian Experience

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Abstract

Introduction. During the COVID-19 pandemic, operating room nurses were at high risk of SARS-CoV-2 infection, making the appropriate use of personal protective equipment (PPE) essential to ensure staff safety and reduce viral transmission. This study aimed to evaluate operating room nurses' adherence to national recommendations on PPE use, investigate the association between PPE selection and COVID-19 infection, and assess nurses' involvement in developing perioperative COVID-19 protocols.

Methods. A cross-sectional exploratory study was conducted in 2021 using an online survey distributed through the Italian Association of Operating Room Nurses (AICO). Data from 153 operating room nurses were analyzed using descriptive statistics and chi-square tests.

Results. Most participants appropriately selected FFP2/FFP3 respirators and eye protection. Twelve nurses (7.8%) reported COVID-19 infection. Greater operating room experience was associated with infection, whereas no significant association emerged between PPE selection and infection. Only 36% of participants were involved in developing COVID-19 protocols.

Discussion. Operating room nurses generally adhered to national PPE recommendations. However, limited involvement in protocol development highlights the need to strengthen frontline staff participation in organizational decision-making during future infectious disease emergencies.

Keywords: Personal Protective Equipment, COVID-19, Perioperative Nursing, Operating Rooms, Infection Prevention, Occupational Health

Introduction

At the end of December 2019, a novel coronavirus (SARS-CoV-2) was identified in Wuhan, China (Zhu et al., 2020). The World Health Organization (WHO) subsequently designated the disease as COVID-19 (Lu et al., 2020; Rothan & Byrareddy, 2020). One month later, COVID-19 was declared a global pandemic (Cucinotta & Vanelli, 2020). The rapid worldwide spread of the disease placed an unprecedented burden on healthcare systems, with hospitals facing major challenges in the management of infected patients (World Health Organization, 2021a). In Italy, as in many other countries, strict public health measures were introduced to contain viral transmission (World Health Organization, 2021b). While the general population was required to remain at home, healthcare professionals continued providing direct patient care, exposing themselves to a substantial risk of infection (Rajnik et al., 2021). During the pandemic, operating rooms remained active for both COVID-19-positive and COVID-19-negative patients (The Lancet, 2020). Dedicated pathways and operating theatres were established to reduce the risk of transmission throughout the perioperative process (Istituto Superiore di Sanità, 2021; Dexter et al., 2020). National scientific societies, including the Italian Association of Operating Room Nurses (AICO) and the Italian Society of Anaesthesia, Analgesia, Resuscitation and Intensive Care (SIAARTI), issued recommendations regarding the appropriate selection and use of personal protective equipment (PPE) (AICO, 2021; SIAARTI, 2020). Appropriate PPE selection, together with adequate training in donning and doffing procedures, represented the cornerstone of infection prevention among perioperative healthcare professionals (Ortega et al., 2020).

Objectives

The primary objective of this study was to evaluate whether operating room nurses selected the appropriate PPE according to AICO and SIAARTI recommendations during the management of patients with SARS-CoV-2 infection. The secondary objective was to investigate the relationship between

inappropriate PPE use and the occurrence of COVID-19 infection among operating room nurses. A third objective was to determine whether perioperative teams had been involved in developing new organizational and clinical protocols for the surgical management of patients with COVID-19.

Methods

Study Design and Setting

A cross-sectional exploratory study was conducted in 2021. An online survey was made available to members of the Italian Association of Operating Room Nurses (AICO) through the association's official website for approximately three months. The survey link was reposted every 15 days to encourage participation.

The present study represents a secondary analysis of additional variables collected within the broader national survey of Italian operating room nurses conducted in 2021. Other outcomes derived from the same survey have been reported elsewhere (Ferraiuolo & Iezzi, 2026).

AICO is an Italian scientific association dedicated to promoting the professional development of perioperative nurses working within surgical teams at both national and international levels. The association supports the development of clinical guidelines addressing perioperative patient management, surgical safety, risk prevention, and quality improvement in operating room practice (AICO, n.d.).

The Italian Society of Anaesthesia, Analgesia, Resuscitation and Intensive Care (SIAARTI) is a scientific society that promotes the integration of clinical practice and research to improve clinical guidelines and therapeutic protocols while fostering collaboration among anaesthesiologists and intensive care professionals throughout Italy (SIAARTI, n.d.).

Participants

A total of 156 nurses voluntarily completed the questionnaire. Three respondents were excluded because they were not members of Italian operating room teams. Consequently,

153 nurses, selected from approximately 2,000 registered AICO members, were included in the final analysis.

Eligible participants were registered nurses actively working within Italian operating room teams involved in the care of patients with COVID-19 who provided informed consent before completing the survey. Nurses not working in COVID-19 settings or not belonging to Italian perioperative teams were excluded. As this was designed as a pilot study, no formal sample size calculation was performed.

Survey Instrument

The questionnaire consisted of 16 items.

The first section included seven questions collecting demographic and professional information, including age, sex, geographical area of employment, professional role, and responsibilities within the operating room team.

The second section consisted of eight multiple-choice questions and one open-ended question investigating the appropriate use of personal protective equipment (PPE) during the perioperative management of patients with COVID-19.

Specifically, participants were asked about:

- the type of respiratory protective device used during surgery on COVID-19-positive patients;
- the type of eye and face protection adopted;
- the airway management devices used during endotracheal intubation;
- the use of additional protective devices to reduce aerosol exposure during intubation;
- the availability of dedicated COVID-19 operating rooms;
- the availability of dedicated support personnel;
- nurses' involvement in developing COVID-19 perioperative protocols;
- occupational SARS-CoV-2 infection during the pandemic.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA).

Descriptive statistics included frequencies,

percentages, means, and standard deviations. Associations between participants' characteristics and study variables were explored using the chi-square (χ^2) test. Statistical significance was established at $p \leq 0.05$.

Ethical Considerations

The study involved adult healthcare professionals and collected no directly identifiable personal or patient data. Participation was voluntary and anonymous, and electronic informed consent was obtained before completion of the questionnaire. The study protocol was approved by AICO (Protocol No. 3, March 1, 2021) and conducted in accordance with applicable data protection regulations and the principles of the Declaration of Helsinki.

Results

Participant Characteristics

A total of 153 operating room nurses completed the survey, and all participants provided informed consent.

Female nurses represented the majority of the sample ($n = 98$, 64.1%). The mean age was 43.8 ± 10.0 years. Most participants worked in Southern Italy ($n = 49$, 32.0%) or Northern Italy ($n = 48$, 31.5%). The mean overall professional experience was 21.7 ± 11.9 years, while the mean operating room experience was 15.6 ± 11.1 years.

Sixty-three participants (41.1%) had fewer than 10 years of perioperative experience, 48 (31.5%) had between 11 and 20 years, and 42 (27.4%) had more than 20 years of experience.

The most frequently reported professional role was scrub nurse ($n = 105$, 68.6%), followed by anaesthesia nurse ($n = 28$, 18.3%) and circulating nurse ($n = 20$, 13.1%).

Participant characteristics are summarized in Table 1.

Personal Protective Equipment Used During Surgery for Patients with COVID-19

The FFP2 respirator was the most frequently reported respiratory protective device, being used by 96 participants (62.7%). Forty-eight nurses (31.3%) reported using an FFP3

respirator, whereas only nine participants (6.0%) used a surgical mask.

Regarding eye and face protection, most respondents reported wearing either a face shield or visor (58.2%). A further 28.1% used a combination of protective goggles and a face shield, while only 9.8% relied exclusively on protective goggles.

Table 1. Participant Characteristics.

Characteristic	n (%)
Female	98 (64.1)
Male	55 (35.9)
Mean age (SD)	43.8 (10.0) years
Northern Italy	48 (31.4)
Central Italy	42 (27.5)
Southern Italy	49 (32.0)
Professional experience, mean (SD)	21.7 (11.9) years
OR experience <10 years	63 (41.2)
OR experience 11–20 years	48 (31.4)
OR experience >20 years	42 (27.4)
Mean OR experience (SD)	15.6 (11.1) years
Scrub nurse	105 (68.6)
Circulating nurse	20 (13.1)
Anaesthesia nurse	28 (18.3)

Note. Percentages are calculated on the total sample (N = 153). Geographical area was not reported for 14 participants.

Airway Management Devices

Videolaryngoscopy was the preferred airway management technique during endotracheal intubation of patients with COVID-19, reported by 85 participants (55.6%).

The Macintosh laryngoscope remained widely used (41.8%), whereas only four respondents (2.6%) reported using a bronchoscope.

Sixty-one nurses (39.9%) indicated that additional protective devices, such as an aerosol box, were employed during intubation to reduce exposure to airborne particles.

Personal protective equipment and airway management practices are summarized in Table 2.

Development of COVID-19 Protocols and Operating Room Organization

Only 55 participants (36.0%) reported being actively involved in developing institutional

protocols for the surgical management of patients with COVID-19.

Most respondents (n = 136) stated that dedicated operating rooms had been established for patients with confirmed SARS-CoV-2 infection.

Furthermore, 68.6% reported providing support to surgical teams outside the operating room during procedures involving patients with COVID-19.

Organizational measures implemented during the COVID-19 pandemic are summarized in Table 3.

Table 2. Personal Protective Equipment and Airway Management Devices.

Variable	n (%)
Respiratory protection	
FFP2 respirator	96 (62.7)
FFP3 respirator	48 (31.3)
Surgical mask	9 (6.0)
Eye/face protection	
Face shield/visor	89 (58.2)
Goggles + visor	43 (28.1)
Goggles only	15 (9.8)
None	6 (3.9)
Intubation device	
Macintosh laryngoscope	64 (41.8)
Videolaryngoscope	85 (55.6)
Bronchoscope	4 (2.6)
Additional aerosol protection	
Yes	61 (39.9)
No	92 (60.1)*

Table 3. Organizational Management During the COVID-19 Pandemic.

Variable	n (%)
Participated in protocol development	55 (36.0)
Did not participate	98 (64.0)
Dedicated COVID-19 operating room available	136 (88.9)
No dedicated operating room	17 (11.1)
Dedicated perioperative nurse available	105 (68.6)
No	26 (17.0)
Sometimes	22 (14.4)

Association Between Type of Respiratory Protection and COVID-19 Infection

Table 4 summarizes the relationship between the type of respiratory protection used during surgery and the occurrence of COVID-19

infection according to professional role.

Among nurses using surgical masks, only one case of COVID-19 infection was reported, involving a scrub nurse. However, this finding should be interpreted cautiously because very few participants used surgical masks.

Most infections occurred among nurses wearing FFP2 respirators (n = 10). Of these, eight (80%) were scrub nurses and two (20%) were anaesthesia nurses.

Only one infection was reported among FFP3 users, again involving a scrub nurse.

Table 4. Association Between Professional Role, Type of Face Mask, and COVID-19 Infection.

Type of face mask	Operating room role	Infected, n	Infected, %	Not infected, n	Not infected, %
Surgical mask	Circulating nurse	0	—	1	12.5
Surgical mask	Anaesthesia nurse	0	—	2	25.0
Surgical mask	Scrub nurse	1	100.0	5	62.5
FFP2 respirator	Circulating nurse	0	—	16	18.6
FFP2 respirator	Anaesthesia nurse	2	20.0	11	12.8
FFP2 respirator	Scrub nurse	8	80.0	59	68.6
FFP3 respirator	Circulating nurse	0	—	3	6.4
FFP3 respirator	Anaesthesia nurse	0	—	13	27.7
FFP3 respirator	Scrub nurse	1	100.0	31	66.0

Overall, scrub nurses experienced the highest number of infections regardless of respirator type, probably reflecting their closer and longer exposure to the surgical field.

Association Between Professional Characteristics and COVID-19 Infection

Overall, twelve participants (7.8%) reported

Table 5. Association Between Operating Room Practice Characteristics and COVID-19 Infection.

Variable	Category	Infected, n	Infected, %	Not infected, n	Not infected, %	p value
Age	<48 years	7	58.3	89	63.1	0.742
Age	>48 years	5	41.7	52	36.9	0.742
Operating room experience	<10 years	2	16.7	61	43.3	0.037
Operating room experience	11–20 years	3	25.0	45	31.9	0.037
Operating room experience	>20 years	7	58.3	35	24.8	0.037
Geographical area of employment	Northern Italy	4	33.3	44	34.6	0.970
Geographical area of employment	Central Italy	4	33.3	38	29.9	0.970
Geographical area of employment	Southern Italy	4	33.3	45	35.4	0.970
Operating room role	Other roles	2	16.7	46	32.6	0.253
Operating room role	Scrub nurse	10	83.3	95	67.4	0.253
Type of respiratory PPE	FFP2 or FFP3 respirator	11	91.7	133	94.3	0.707
Type of respiratory PPE	Surgical mask	1	8.3	8	5.7	0.707
Eye and face protection in the operating room	Goggles and/or face shield	12	100.0	135	95.7	0.466
Eye and face protection in the operating room	None	0	0.0	6	4.3	0.466
Endotracheal intubation device	Macintosh laryngoscope	3	25.0	61	43.3	0.218
Endotracheal intubation device	Videolaryngoscope	9	75.0	80	56.7	0.218
Protective device used during endotracheal intubation	Yes	5	41.7	56	39.7	0.895
Protective device used during endotracheal intubation	No	7	58.3	85	60.3	0.895

occupational COVID-19 infection. Associations between professional and perioperative practice characteristics and COVID-19 infection are presented in Table 5.

Operating room experience was the only variable significantly associated with infection (χ^2 , $p = 0.037$). Nurses with more than 20 years of perioperative experience showed the highest infection rate.

No statistically significant associations were found between COVID-19 infection and age, geographical region, professional role, type of respiratory protection, eye protection, intubation device, or use of additional aerosol-protection devices.

Discussion

This study investigated whether Italian operating room nurses adhered to national recommendations for the management of patients with COVID-19 and the appropriate use of personal protective equipment (PPE) (AICO, 2021; SIAARTI, 2020). The findings provide valuable insight into perioperative clinical practice during the pandemic and may support healthcare organizations in improving preparedness for future infectious disease emergencies (FNOPI, 2022).

The COVID-19 pandemic placed unprecedented pressure on healthcare systems worldwide (SAGES, 2022). Maintaining the safety of healthcare professionals while ensuring continuity of surgical care became a major organizational challenge (CDC, 2021). During the first pandemic waves, shortages of PPE and rapidly evolving recommendations increased uncertainty among perioperative teams (AORN, 2021). Consequently, evaluating compliance with national guidelines is essential for improving future emergency preparedness.

Appropriate Use of Personal Protective Equipment

Overall, the results demonstrate a high level of adherence to national recommendations. More than 90% of participants reported using FFP2 or FFP3 respirators when caring for patients with COVID-19, suggesting widespread implementation of infection prevention measures within Italian operating rooms.

Similarly, almost all participants reported wearing appropriate eye protection, either as a face shield or in combination with protective goggles. Considering that ocular mucosa may

represent a potential route of viral transmission, these findings indicate good compliance with recommended protective measures.

Nevertheless, a small proportion of nurses continued to use surgical masks during procedures involving patients with COVID-19. Although this represented only a limited number of participants, inappropriate PPE selection may increase occupational risk while simultaneously reflecting inadequate dissemination or implementation of institutional recommendations.

Interestingly, the choice of respirator appeared to vary according to professional role. Current national recommendations advise that healthcare professionals performing aerosol-generating procedures, particularly anaesthesia personnel, should preferentially wear FFP3 respirators because of their higher filtration efficiency. However, FFP3 respirators were more frequently reported among scrub nurses than anaesthesia nurses, suggesting that PPE allocation was not always fully aligned with exposure risk (AICO, 2021; SIAARTI, 2020).

Airway Management and Aerosol Protection

The widespread use of videolaryngoscopy observed in this study is consistent with international recommendations advocating techniques that maximize the distance between healthcare professionals and patients during airway management (Peng et al., 2020; Tompkins et al., 2010).

Many participants also reported using additional protective devices, including aerosol boxes, during endotracheal intubation. These devices were introduced in several institutions during the early stages of the pandemic despite limited evidence regarding their effectiveness (Coccolini et al., 2020). Their adoption reflects the rapid implementation of innovative protective strategies under emergency conditions.

COVID-19 Infection Among Operating Room Nurses

Only 7.8% of participants reported occupational COVID-19 infection during the study period.

Interestingly, no statistically significant association emerged between the type of

respiratory protection used and infection. This finding suggests that SARS-CoV-2 transmission is influenced by multiple factors beyond PPE selection alone, including duration of exposure, environmental ventilation, adherence to donning and doffing procedures, community transmission, and overall infection prevention practices.

Conversely, nurses with more than 20 years of operating room experience demonstrated a significantly higher likelihood of infection. Although the study design does not allow causal inference, this finding may reflect increased cumulative exposure or the assignment of more experienced nurses to high-risk surgical procedures throughout the pandemic.

Furthermore, scrub nurses accounted for most reported infections. Their continuous proximity to the sterile surgical field and prolonged exposure during operative procedures may explain this observation.

Staff Involvement in Developing COVID-19 Protocols

One of the most important findings of this study concerns the limited involvement of frontline nurses in developing institutional COVID-19 protocols.

Only approximately one-third of participants reported participating in protocol development, despite being directly responsible for implementing these procedures in clinical practice.

Clinical protocols represent an essential tool for translating scientific evidence into standardized perioperative care (Wang et al., 2020). Excluding frontline professionals from protocol development may reduce staff engagement, limit protocol applicability, and negatively influence adherence to organizational changes (Thiruvengkatarajan et al., 2020).

Future emergency planning should therefore promote multidisciplinary collaboration involving perioperative nurses, anaesthesia professionals, surgeons, and hospital leadership to ensure that clinical protocols are both evidence-based and operationally feasible (Calamandrei et al., 2008; World Health Organization, 2020).

Strengths and Limitations

This study represents one of the first national surveys investigating PPE use among Italian operating room nurses during the COVID-19 pandemic.

However, several limitations should be acknowledged. First, the cross-sectional design prevents conclusions regarding causality. Second, all data were self-reported and therefore may be subject to recall and response bias. Third, participants were recruited exclusively through AICO membership, potentially limiting the generalizability of the findings to all Italian operating room nurses. Finally, the relatively low number of COVID-19 infections reduced the statistical power to detect associations between PPE use and infection.

Despite these limitations, the study provides valuable evidence regarding perioperative practice during a public health emergency and highlights important organizational aspects that may inform future preparedness strategies.

Conclusions

The COVID-19 pandemic emphasized the critical importance of protecting perioperative healthcare professionals while maintaining safe surgical services.

This exploratory study demonstrates that Italian operating room nurses generally adhered to national recommendations regarding the appropriate use of personal protective equipment during the care of patients with COVID-19. Compliance with recommended respiratory and eye protection was high, suggesting successful implementation of infection prevention measures across participating institutions.

Nevertheless, frontline nurses were only marginally involved in developing institutional COVID-19 protocols. Greater participation of perioperative professionals in organizational decision-making may improve protocol implementation, strengthen staff engagement, and enhance preparedness for future public health emergencies.

Future research should evaluate the long-term impact of infection prevention strategies, investigate factors influencing PPE adherence, and assess the effectiveness of multidisciplinary approaches to emergency planning within perioperative settings.

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Nursing Interventions for a Patient With Sudden Cardiac Arrest in the Operating Room: A Case Report

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Abstract

Introduction. Intraoperative sudden cardiac arrest is a rare, life-threatening event requiring immediate recognition, coordinated resuscitation, and structured perioperative nursing care. This case report describes the application of standardized NANDA International (NANDA-I), Nursing Outcomes Classification (NOC), and Nursing Interventions Classification (NIC) terminology to nursing management of an intraoperative cardiac arrest.

Case Presentation. A 62-year-old man with a history of myocardial infarction, coronary stent placement, hypertension, hypercholesterolemia, and hypothyroidism underwent total left knee arthroplasty. Following tourniquet release, the patient developed severe hypotension that rapidly progressed to pulseless electrical activity and subsequently ventricular fibrillation.

Intervention. Advanced life support was initiated, including high-quality cardiopulmonary resuscitation, epinephrine administration, endotracheal intubation, defibrillation, continuous physiological monitoring, and subsequent transfer to intensive care. Nursing care was structured according to Carpenito's Bifocal Model and the NANDA-I–NOC–NIC framework, with particular emphasis on cardiovascular surveillance, emergency management, airway management, defibrillation, and continuity of care.

Outcome. Return of spontaneous circulation was achieved, although a subsequent cardiac arrest required further resuscitation. Coronary angiography identified an anterior ST-elevation myocardial infarction requiring percutaneous coronary intervention. The patient subsequently recovered neurological and functional capacity and regained independence in activities of daily living.

Conclusion. Standardized nursing terminology provided a structured framework for documenting clinical reasoning, interventions, and measurable outcomes during a complex intraoperative emergency, while supporting continuity of care across perioperative and critical care settings.

Keywords: Cardiac Arrest, Perioperative Nursing, Operating Rooms, Cardiopulmonary Resuscitation, Nursing Process, Standardized Nursing Terminology

Introduction

Sudden Cardiac Arrest (SCA), defined as death of presumed cardiac etiology occurring within 1 hour of symptom onset or 24 hours following the last observed healthy status, remains the third leading cause of mortality in Europe (Andersen et al., 2019). Extensive research has been conducted to elucidate the etiologies and contributing factors underlying cardiac arrest (CA), as well as to quantify variations in incidence both within and across nations. While the factors influencing outcomes following Out-of-Hospital Cardiac Arrest (OHCA) and In-Hospital Cardiac Arrest (IHCA) are well-established, significant national variability persists regarding both incidence and patient outcome (Gräsner et al., 2021).

Cardiac arrest is mechanistically defined as the abrupt cessation of cardiac mechanical activity, leading to hemodynamic collapse. Post-mortem examinations may identify a cardiac etiology, although not all SCA cases have an identifiable cause (ESC Scientific Document Group, 2023).

Coronary Artery Disease (CAD) accounts for over 75% of SCA cases in developed countries. Despite a concurrent increase in CAD incidence over recent decades, there has been a notable decline in overall cardiovascular mortality (Italian Resuscitation Council, 2021). Early intervention for CAD represents the most effective preventive measure against SCA. Studies suggest that CA and SCA may be the initial presentation of CAD in genetically predisposed individuals, with acute myocardial infarction or ischemia being the typical underlying diagnosis. Consequently, the prompt identification of CAD and aggressive management of atherosclerotic cardiovascular disease risk factors constitute the optimal strategy for minimizing the risk of CA and SCA. Prompt Cardiopulmonary Resuscitation (CPR) is critical for improving outcomes in patients who experience IHCA (Yow et al., 2025).

The annual incidence of IHCA in Europe ranges from 1.5 to 2.8 per 1,000 hospital admissions. Factors associated with survival include the presenting rhythm, the location of the arrest, and the level of patient monitoring at the time of collapse. Survival rates to 30 days or hospital discharge range widely, from 15% to 34% (Gräsner et al., 2021).

In European countries that routinely practice Withdrawal of Life-Sustaining Treatment (WLST), a favorable neurological outcome is observed in over 90% of surviving patients, with most able to return to work. Conversely, in regions where WLST is not a common practice, adverse neurological outcomes are more frequent (50%, with 33% of patients remaining in a persistent vegetative state). Even among survivors with a favorable neurological status, residual neurocognitive deficits, chronic fatigue, and emotional issues are prevalent, leading to diminished quality of life. Furthermore, both patients and their relatives are at risk for developing post-traumatic stress disorder (Haywood et al., 2018).

Multiple factors determine the outcome for patients suffering an IHCA. These are broadly categorized as non-modifiable factors, such as patient age, sex, and comorbidities (Bircher et al., 2019), and modifiable factors.

A modifiable factor of considerable clinical importance is the in-hospital location of the cardiac arrest. When CA occurs in a general medical ward, patients are typically not adequately monitored, and the arrest may be unwitnessed. These circumstances are consistently associated with a lower probability of survival (Al-Dury et al., 2017).

Electrocardiogram (ECG) monitoring at the time of collapse is associated with a 38% reduction in the risk of death following IHCA. The presence of Ventricular Fibrillation (VF) as the initial rhythm is predictive of a higher survival probability. The faster the ECG is recorded, the greater the likelihood of detecting a shockable rhythm such as VF (Thorén et al., 2020). Furthermore, a

shorter time interval to the initiation of treatment is associated with increased survival in both defibrillable and non-defibrillable IHCA rhythms (Italian Resuscitation Council, 2021).

Finally, an essential factor influencing post-resuscitation survival is the hospital's policy regarding the decision to initiate CPR. Timely CPR significantly enhances the likelihood of successful defibrillation and subsequent IHCA recovery (Thorén et al., 2020).

Cardiac arrest rhythms are broadly classified as either defibrillable (VF or pulseless Ventricular Tachycardia - VT) or non-defibrillable (Asystole or Pulseless Electrical Activity - PEA). The primary difference in management for defibrillable rhythms is the immediate requirement for attempted defibrillation. However, other interventions including high-quality chest compressions with minimal interruptions, advanced airway and ventilation management, vascular access, adrenaline administration, and the identification and treatment of reversible causes are standard components of resuscitation for all CA rhythms (Soar et al., 2021).

The Advanced Life Support (ALS) algorithm (Figure 1) provides a comprehensive framework for all these key interventions.

ABCDE indicates Airway, Breathing, Circulation, Disability, Exposure/Environment; CPR Cardiopulmonary Resuscitation; ECG Electrocardiogram; PEA Pulseless Electrical Activity; PaCO₂ partial pressure of arterial carbon dioxide; ROSC Return of Spontaneous Circulation; SpO₂ Arterial oxygen saturation; VF Ventricular Fibrillation; VT Ventricular Tachycardia. Source: Italian Resuscitation Council (2021).

Methods

Study Design

This study was conducted in accordance with the Case Report methodological design, adhering strictly to the international reporting criteria defined by the CARE (CAsE REport) guidelines to ensure transparency, accuracy, and completeness of the clinical reporting.

Theoretical and Methodological Framework

The nursing process was structured and

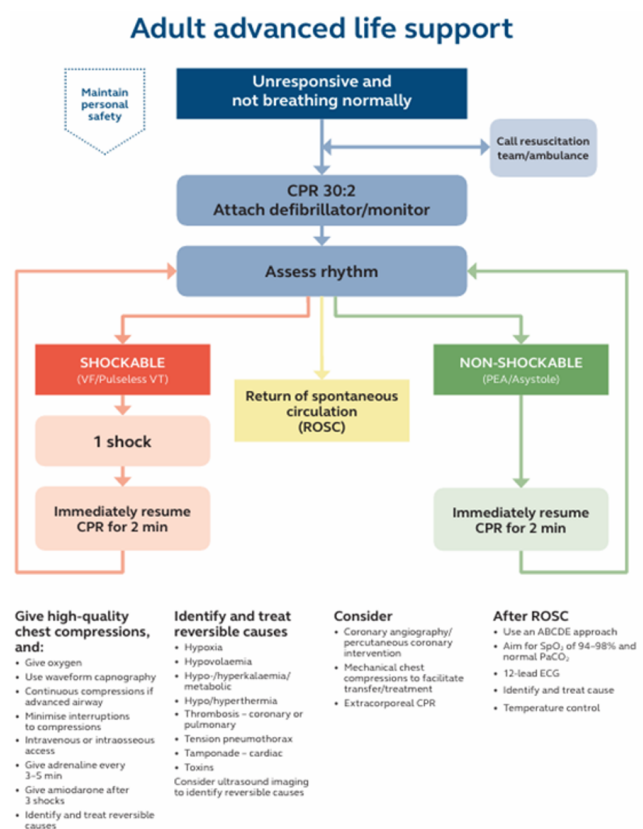


Figure 1. Advanced Life Support Algorithm

operationalized through the integrated application of standardized taxonomies: NANDA-I (North American Nursing Diagnosis Association International), NOC (Nursing Outcomes Classification), and NIC (Nursing Interventions Classification). To guide clinical reasoning within a high complexity emergency setting, Carpenito's Bifocal Model of Clinical Practice (Carpenito, 2021) was adopted. This approach facilitated a clear distinction between:

- Collaborative Problems: pathophysiological complications (such as sudden cardiac arrest) that the nurse monitors to detect onset or changes in status. These require interdependent (medical-nursing) interventions based on the rigorous application of advanced protocols (ALS/ILCOR).
- Nursing Diagnoses: human responses and clinical judgments falling within the domain of professional autonomy, specifically focused on proactive surveillance, risk management and the evaluation of nursing sensitive outcomes.

Ethical Considerations

This case report was based on routine clinical

care. Written informed consent was obtained from the patient for the use and publication of clinical information. Patient privacy and confidentiality were maintained throughout the study.

Case Presentation

Preoperative History and Assessment

A 62 year old male underwent total left knee arthroplasty and a Lipogems procedure on the right knee. The patient's medical history included a prior myocardial infarction in 2019, treated with the placement of two stents, as well as arterial hypertension, hypercholesterolemia and hypothyroidism, all of which were pharmacologically stable at the time of surgery. Preoperative cardiological evaluation confirmed clinical stability (ECG: sinus rhythm, intervals within normal limits). Laboratory findings revealed a hemoglobin level of 10.4 g/dL attributed to chronic hemorrhoidal disease; consequently, two units of packed red blood cells (PRBCs) were cross matched for the procedure. Physical examination showed a Mallampati score of 2; the patient was classified as ASA Physical Status II.

Timeline of Events

The patient was admitted to the holding area at 15:30. Following counseling regarding the anesthetic and surgical procedures, premedication consisting of 2 mg of midazolam and 100 mcg of fentanyl was administered. Plexus anesthesia was performed via a saphenous nerve block, followed by spinal anesthesia.

The patient was transferred to the operating room at 16:30. A pneumatic tourniquet was applied to the left thigh and inflated to 300 mmHg, followed by skin disinfection and surgical draping.

At 17:30, following tourniquet release, vessel hemostasis and wound closure, the patient developed marked hypotension. This condition proved refractory to vasopressors (etilefrine) and rapidly progressed to a lipothymic episode (Table 1). The patient was transferred to the Intensive Care Unit (ICU) and placed on mechanical ventilation in CPAP/ASB mode. An Arterial Blood Gas (ABG) analysis and a 12 lead Electrocardiogram (ECG) were performed.

Table 1. Cascade of events in the Operating Room Following the Lipothymic Episode.

Estimated Time Post-	Clinical Event/Monitoring	Therapeutic Intervention	Key Notes and Details
T0	Rhythm present on monitor, Pulse absent (PEA)	Call for support staff.	Diagnosis of Pulseless Electrical Activity (PEA) - a form of cardiac arrest
T0 + 30 sec	PEA continues	Initiation of CPR (Chest Compressions). Arrival of support staff, preparation of medications and defibrillator	Adherence to advanced life support protocols
T0 + 1 min (approx.)	PEA	Administration of 1 ampoule of Epinephrine (Adrenaline)	First vasopressor drug per CA guidelines
T0 + 1 min and 30 sec (approx.)	Transformation into Ventricular Fibrillation (VF)	Ootracheal Intubation (OTI) performed and mechanical ventilator connected	VF is a shockable rhythm Airway security ensured
T0 + 2 min (approx.)	VF	1st SHOCK (150 J)	First defibrillation (Biphasic at low Joule setting if machine allows)
T0 + 3 min (approx.)	Post-shock	Resumption of CPR	Necessary to maintain cerebral and coronary perfusion
T0 + 3 and 30 sec (approx.)	Post-shock	Administration of 1 ampoule of Epinephrine (total 2 ampoules)	Second dose of vasopressor
T0 + 4 min (approx.)	Persistence of VF	2nd SHOCK (200 J)	Second defibrillation with energy escalation.
T0 + 4 min and 30 sec (approx.)	ROSC (Return of Spontaneous Circulation)	CO2 waveform present (EtCO2 > 10 mmHg)	Return of spontaneous circulation confirmed by palpable pulse and capnography
Post-ROSC	Hemodynamic stability	Recovery of spontaneous respiratory activity Absence of consciousness	Observation of Miotic Pupils (likely post-hypoxia or residual)
CA Time	Total Resuscitation Duration	4 minutes	Total duration of cardiac arrest, from PEA to ROSC
Immediately Post-ROSC	Stabilization	Transfer to Intensive Care Unit (ICU)	Requirement for post-resuscitation care and temperature control (Targeted Temperature Management - TTM)

At 17:50, a new episode of Cardiac Arrest (CA) occurred. The patient was ventilated in Intermittent Positive Pressure Ventilation (IPPV) mode (FiO 21%), and resuscitation efforts were initiated with External Cardiac Massage (ECM) and adrenaline infusion. After the third ampule of adrenaline combined with ECM, a hemodynamically stable cardiac rhythm was recovered, and central and peripheral pulses reappeared (CA time: 8 minutes).

The on-call cardiologist decided to proceed with a hemodynamic study.

At 18:10, the patient was taken to the Cardiac Catheterization Laboratory. The patient was hemodynamically supported by an adrenaline infusion 0.3 mcg/kg/min with a maintained Mean Arterial Pressure (MAP) > 60 mmHg but remained tachycardic HR >100 bpm. Electrolyte imbalances were corrected.

The patient was diagnosed with an anterior ST-Elevation Myocardial Infarction (STEMI). Two coronary stents were deployed to treat a thrombotic occlusion within a prior periosteal stent in the Left Anterior Descending (LAD) artery and a thrombotic occlusion at the LAD bifurcation.

During the night, the patient presented with hypotension and tachycardia despite ongoing vasoactive amine infusions. Lactate levels were increasing, despite bicarbonate correction. Arterial saturation, pH, and urine output remained relatively stable.

The interventional cardiologist was contacted and placed an Intra-Aortic Balloon Pump (IABP).

Intraoperative Nursing Assessment

The patient is admitted to the operating room at 4:30 PM, awake and oriented. The assisted person's state of consciousness and vital signs, oxygen saturation, and ECG were monitored, as the patient was premedicated with 2 mg of Midazolam and 100 mcg of Fentanyl.

BP 105/59 mmHg, HR 55 bpm, SpO₂ 98% with 2 L/min oxygen therapy via nasal cannula.

At 5:30 PM, after removing the tourniquet, 1000 mL of crystalloids and 2 mg of Effortil were infused, with a blood loss of 250 mL.

Within a few minutes, we observed a hypotensive collapse (pressure drop) resistant to vasopressors (Effortil), followed by a syncopal episode (lipothymia).

The Rationale for the NNN Linkage (NANDA-I, NOC, NIC)

The NANDA-I, NOC and NIC (NNN) taxonomies provide a standardized framework that enables nurses to rigorously evaluate a patient's health status. This taxonomic linkage serves as a clinical roadmap to identify both expected and actual outcomes throughout the six phases of the nursing process:

- Phase 1: comprehensive initial assessment (Holistic assessment phase).
- Phase 2: formulation of the nursing diagnosis (Diagnostic statement phase).
- Phase 3: establishment of expected health outcomes, collaboratively determined with the patient and their family (Planning of expected outcomes).
- Phase 4: planning of nursing interventions and specific activities (Intervention planning phase).
- Phase 5: implementation of nursing interventions and clinical activities (Execution phase).
- Phase 6: evaluation of clinical results leading to definitive changes in the patient's health status (Outcome evaluation phase) (Herdman et al., 2024).

Nursing Care Plan

In alignment with Carpenito's Bifocal Model, the cardiac arrest was managed as a "Collaborative Problem", as it represents a pathophysiological complication requiring interdependent (medical-nursing) interventions. Conversely, the NANDA-I taxonomies were utilized to describe human responses and to structure clinical reasoning and surveillance.

Table 2 presents the nursing diagnosis, interventions, and activities of the care plan according to the NANDA-I and NIC classifications. Figure 2 illustrates the Likert scale used to evaluate the outcome indicators of the implemented interventions. Table 3 delineates the linkage between NANDA-I, NOC and specific outcome indicators.

Identified NANDA-I Diagnoses

00311 Risk for Compromised Cardiovascular

Function

Methodological Note: this risk diagnosis served as the framework for proactive clinical surveillance during the preoperative phase and for intensive post ROSC monitoring. It does not define the arrest in progress, but rather the patient's vulnerability, which guides both preventive and post acute planning. The acute arrest event itself was managed as a physiological complication (Collaborative Problem).

Identified NIC

- Vital Signs Monitoring (6680): continuous assessment of HR, heart rhythm, SpO₂ and EtCO₂. The documentation of baseline values allowed for the early detection of subtle physiological shifts that preceded the collapse.
- Emergency Management and Defibrillation (6200, 4095): during the collaborative problem (SCA), the nurse ensured high quality CPR, minimizing pre-shock pauses and coordinating safety protocols during defibrillation.
- Airway Management and Electrolyte Monitoring (3120, 2020): assistance during endotracheal intubation (ETI) and monitoring of electrolyte imbalances (K⁺, Ca⁺⁺) associated with prolonged resuscitative efforts.
- Health System Guidance and Transport (7960, 7892): management of the critical clinical handoff to the Intensive Care Unit (ICU).

Identified NOC

The effectiveness of the interventions was measured through the outcome Cardiopulmonary Status (0414). Key indicators (BP, HR, Rhythm) progressed from a score of 1 (Severe deviation from normal range) during the event to 5 (No deviation from normal range) during the post-operative stability phase.

In the perioperative setting, particularly during a SCA event, the nursing role evolves rapidly from clinical surveillance to the active management of advanced life support.

Vital Signs Monitoring and Surveillance (NIC 6680)

The nurse's primary responsibility involves the continuous monitoring of vital signs. This activity encompasses not only the assessment of heart rate, rhythm, and oxygen saturation but also the critical analysis of end-tidal carbon dioxide (EtCO₂) and core body temperature. Vigilance regarding peripheral pulses and skin hydration status (e.g., diaphoresis) is essential for the early identification of hemodynamic instability. Systematic documentation of baseline values enables the nursing team to recognize subtle physiological shifts that may precede cardiovascular collapse.

Emergency Management and Defibrillation (NIC 6200, 4095)

Upon the onset of SCA in the operating room or Post-Anesthesia Care Unit (PACU), the nurse initiates emergency management protocols. This involves the immediate activation of the emergency response system and the commencement of cardiopulmonary resuscitation (CPR) in accordance with current BLS/ALS guidelines (30:2 compression to ventilation ratio). A crucial nursing intervention is "Defibrillator Management": the nurse ensures rapid pad placement, minimizes the pre-shock pause, and guarantees safety by coordinating the "clear" command prior to shock delivery. The nurse's ability to minimize interruptions in chest compressions is directly correlated with improved clinical outcomes during the perioperative phase.

Airway Management and Metabolic Support (NIC 3120, 2020)

Advanced airway support requires close collaboration between the nurse and the anesthesiologist. The nurse assists in the endotracheal intubation procedure by preparing the equipment, pre-oxygenating the patient, and confirming correct tube placement through auscultation and capnography. Simultaneously, "Electrolyte Monitoring" is vital; the nurse monitors the ECG for rhythm alterations associated with potassium or calcium imbalances and assesses signs of acid-base disturbances, which are frequent during prolonged resuscitative efforts.

Table 2 (part 1). Nursing Diagnoses, Interventions, and Activities according to the NANDA-I and NIC Classifications.

NANDA-I Diagnosis	Nursing Interventions (NIC)
00311 Risk for Compromised Cardiovascular Function (Susceptibility to an alteration in the transport of substances, body homeostasis, removal of metabolic waste products from tissues, and/or organ function, which may compromise health)	6680 Vital Signs Monitoring • Monitor blood pressure, pulse, temperature, and respiratory status, as appropriate • Monitor level of consciousness (LOC) • Document baseline and significant vital sign changes • Initiate and manage continuous core temperature monitoring, as appropriate • Monitor and report signs and symptoms of hypothermia and hyperthermia • Monitor presence and quality of peripheral pulses • Simultaneously palpate apical and radial pulses and note any differences, as appropriate • Monitor heart rhythm and rate • Monitor oxygen saturation • Monitor skin color and moisture • Identify possible etiologies for vital sign changes
	6200 Emergency Management • Activate the Emergency Medical Services (EMS) system • Retrieve the Automated External Defibrillator (AED) or ensure that someone is retrieving the AED • Perform interventions to support vital functions (Basic Life Support/Advanced Life Support) • Assess for signs and symptoms of cardiac arrest • Call for help in the event of absence of breathing or abnormal breathing (agonal gasps) and unresponsiveness • Utilize appropriate infection control precautions while rendering care • Connect the AED and follow specific prompts/actions, as appropriate • Ensure rapid defibrillation • Initiate Cardiopulmonary Resuscitation (CPR) with 30 chest compressions at the recommended rate and depth, allowing for full chest recoil between compressions, minimizing interruptions to compressions, and avoiding excessive ventilation • Minimize the interval between the cessation of chest compressions and the electrical shock (pre-shock pause) • Implement vital function support actions tailored to the most probable cause of arrest (e.g., cardiac or respiratory etiology) • Ensure airway patency • Deliver two rescue breaths after completing the first 30 chest compressions
	4095 Defibrillator Management • Initiate Cardiopulmonary Resuscitation (CPR) • Prepare equipment for immediate defibrillation in the absence of a pulse and consciousness, concurrent with CPR • Continue CPR when external defibrillation is not being performed. • Apply the electrodes/pads as recommended by the defibrillator instructions • Place the automated monitoring devices on the patient (Automated External Defibrillator (AED) electrodes or monitor sensors) • Position the pads and electrodes avoiding clothing or linen, as appropriate • Charge the defibrillator to the appropriate energy level (appropriate Joule setting) • Employ safety precautions before delivering the shock (e.g., verbalize "I'm clear, you're clear, everybody clear," ensuring that no one, including yourself, is touching the patient) • Assess the outcome and repeat defibrillation if indicated • Minimize interruptions in chest compressions for the unconscious patient • Document all events appropriately
	3120 Airway Management – Intubation • Select the correct type and size of oropharyngeal airway (OPA) tube • Collaborate with the physician/anesthesiologist in the selection of the type and size of the endotracheal tube (ETT) • Pre-oxygenate with 100% oxygen • Suction the mouth and oropharynx • Insert the oropharyngeal airway, ensuring it reaches the base of the tongue to prevent the tongue from falling backward (posterior displacement) • Monitor for the potential onset of dyspnea, snoring sounds (stertor), or inspiratory stridor once the oropharyngeal airway is in place • Assist with the endotracheal intubation procedure by preparing the necessary materials and equipment, administering prescribed medications, and monitoring for the potential onset of complications during the maneuver • Auscultate the chest after intubation • Auscultate for bilateral breath sounds before inflating the cuff of the esophageal obturator airway (if applicable/used) or ETT • Observe for systematic chest wall movement/rise • Monitor oxygen saturation (SpO₂) with a non-invasive pulse oximeter and CO₂ detection (Capnography/Capnometry) • Secure the endotracheal tube with tape, tie, or other commercially available securing devices

Table 2 (part 2). Nursing Diagnoses, Interventions, and Activities according to the NANDA-I and NIC Classifications.

NANDA-I Diagnosis	Nursing Interventions (NIC)
00311 Risk for Compromised Cardiovascular Function (Susceptibility to an alteration in the transport of substances, body homeostasis, removal of metabolic waste products from tissues, and/or organ function, which may compromise health)	2020 Electrolyte Monitoring • Monitor for the onset of potential acid-base imbalance • Identify possible causes of the electrolyte imbalance • Recognize and report the presence of electrolyte imbalance • Monitor for blood loss/hemorrhage • Monitor the degree of ventilation adequacy • Monitor the Electrocardiogram (ECG) tracing for any changes correlated with potassium, calcium, and magnesium levels • Observe for changes in peripheral sensation such as numbness and tremors • Monitor for the presence of nausea and vomiting
	7960 Health Information Exchange • Identify current nursing and medical diagnoses • Describe ongoing nursing interventions/care provided • Identify necessary equipment and supplies for patient care/support • Coordinate care with other healthcare professionals
	7892 Intra-facility Transfer • Facilitate coordination and communication prior to transport • Determine the quantity and type of assistance required • Provide adequate personnel to assist with the transport • Provide the appropriate equipment to execute the transport • Ensure that the patient's new destination is ready • Move the patient utilizing the required equipment • Monitor the patient during transport • Provide a clinical report/handoff regarding the patient to the receiving unit/department

Care Coordination and Interfacility Transport (NIC 7960, 7892)

Effective healthcare information exchange is fundamental during the transition from the operating room to the PACU or the ICU. The nurse coordinates the "Interfacility Transport", ensuring the provision of a comprehensive and detailed clinical handoff. This includes an analytical description of the interventions performed, medications administered, and the patient's response to treatment. Ensuring that the receiving unit is fully operational and equipped with the necessary resources (e.g., ventilators, monitors) represents the final, critical step in guaranteeing continuity of care and patient safety following a cardiac event.

Scale used to assess the outcome indicators:	
1.	Severe deviation from the standard range
2.	Substantial deviation from the standard range
3.	Moderate deviation from the standard range
4.	Mild deviation from the standard range

Figure 2. Likert Scale Used to Evaluate the Outcome Indicators of the Care Plan.

Evaluation of Nursing Outcomes and Cardiopulmonary Status

The efficacy of nursing interventions was quantitatively evaluated using the Nursing Outcomes Classification (NOC), focusing the analysis on the outcome Cardiopulmonary Status (0414). This outcome provides a structured framework for monitoring the patient's transition from a state of critical instability during Sudden Cardiac Arrest to physiological stabilization.

Hemodynamic Recovery and Perfusion

Indicators for Systolic Blood Pressure (041401), Diastolic Blood Pressure (041402), and Apical Heart Rate (041404) were employed to track the effectiveness of resuscitative maneuvers. During the acute phase of the SCA, these parameters exhibited a "Severe deviation from normal range" (Score 1). Following the implementation of the ALS protocol and effective defibrillation, the nursing team monitored the progressive improvement of these values toward a state of "No deviation from normal range" (Score 5), signaling the Return of Spontaneous Circulation (ROSC). The presence and quality of Peripheral

Table 3. Relationship between NANDA-I, NOC, and outcome indicators.

Relationship between NANDA-I, NOC, and outcome indicators					
NANDA-I 00311: Risk for Compromised Cardiovascular Function					
NOC 0414: Cardiopulmonary Status					
Outcome Measure	Severe deviation from the standard range 1	Substantial deviation from the standard range 2	Moderate deviation from the standard range 3	Mild deviation from the standard range 4	No deviation from the standard range 5
INDICATORS					
041401 Systolic Blood Pressure (SBP)	1	2	3	4	5
041402 Diastolic Blood Pressure (DBP)	1	2	3	4	5
041403 Peripheral Pulses	1	2	3	4	5
041404 Apical Heart Rate	1	2	3	4	5
041405 Heart Rhythm	1	2	3	4	5
041406 Respiratory Rate	1	2	3	4	5*
041407 Respiratory Rhythm	1	2	3	4	5*
041411 Cardiac Index	1	2	3	4	5
041412 Oxygen Saturation (SpO2)	1	2	3	4	5*

Note. NOC outcome and indicators based on Moorhead et al. (2020). *Intubated and mechanically ventilated patient.

Pulses (041403) and the normalization of Cardiac Rhythm (041405) served as the primary clinical markers for the restoration of adequate tissue perfusion and cardiac output.

Respiratory Management in the Intubated Patient

As detailed in Table 3, indicators for Respiratory Rate (041406), Respiratory Rhythm (041407) and Oxygen Saturation (041412) were assessed within the context of an intubated and mechanically ventilated patient. In the immediate post ROSC phase, maintaining an SpO2 score of 5 (No deviation) was achieved through precise nursing management of ventilator settings and continuous capnography monitoring. The nurse's role was pivotal in ensuring that mechanical ventilation effectively compensated for impaired respiratory function, thereby preventing secondary hypoxic organ damage.

Clinical Significance of Standardized Monitoring

The use of a 5 point Likert scale to measure Cardiac Index (041411) and other hemodynamic variables allowed the surgical and anesthesia teams to maintain a real-time assessment of the patient's status. For the professional nurse, these NOC indicators are not merely numerical data

but essential tools for clinical decision-making. By identifying early "Substantial" or "Moderate" deviations (Scores 2–3), the nurse can initiate immediate corrective actions, such as the titration of vasoactive infusions or alerting the anesthesia team, ensuring patient safety during the high risk transition from the operating room to the PACU or ICU.

Follow-up and Functional Recovery

In the subsequent days, following ventilator weaning, the discontinuation of vasopressors (amines), and the removal of the Intra-Aortic Balloon Pump (IABP), the patient regained phonatory capacity, which was initially delayed. In the following weeks, the patient resumed mobilization to a chair, demonstrating full motor recruitment across all four limbs and the absence of neurological deficits. Ultimately, the patient achieved a complete recovery of Activities of Daily Living (ADLs).

Discussion

The identification of the NANDA-I nursing diagnosis "Risk for Compromised Cardiovascular Function (00311)" proved to be pivotal in the perioperative context. In accordance with

current literature (Herdman et al., 2024), "risk-type" diagnoses empower nurses to implement proactive clinical surveillance. In the present case, diagnostic accuracy facilitated the anticipation of the SCA event, allowing for a seamless transition from routine nursing care to active emergency management. Previous studies (Lopes et al., 2020) emphasize that the implementation of standardized nursing languages reduces clinical ambiguity in high-complexity environments, such as the operating room.

The fundamental principles of cardiac arrest management, such as early defibrillation and the delivery of high-quality CPR, remain constant requirements in both IHCA and OHCA settings. Within the hospital environment, the immediate availability of qualified personnel and specialized equipment provides a critical window for rapid arrest recognition and the timely initiation of treatment (Soar et al., 2021). In this scenario, the swift transition from recognizing vital sign derangements to commencing high-quality CPR and initiating etiological treatment (identifying the "4 Hs and 4 Ts") is not merely desirable but absolutely essential for patient survival (Al-Dury et al., 2017; Bircher et al., 2019; Haywood et al., 2018; Italian Resuscitation Council, 2021; Soar et al., 2021; Thorén et al., 2020; Yow et al., 2025).

The implementation of the NIC interventions Emergency Management (6200) and Defibrillator Management (4095) aligns with the international gold standards established by the American Heart Association (AHA) and the European Resuscitation Council (ERC). However, the NIC taxonomy adds significant value by operationalizing specific nursing activities, such as "minimizing interruptions in chest compressions" and "ensuring safety during shock delivery." The standardization of these activities ensures coordinated action within the perioperative team, thereby reducing response times a critical factor in achieving the Return of Spontaneous Circulation (ROSC) (Soar et al., 2021).

The surgical suite represents an ideal environment to maximize every link in the Chain of Survival, provided that the first link - "recognition" - is robust. Mere monitor activation is insufficient; instead, the proactive interpretation of clinical trends is essential. Unlike a general ward, the operating room benefits from the immediate presence of a highly qualified team. The challenge lies in transforming

this personnel into a cohesive and reactive crisis team whose objective is to act within the "Golden Minute" of the arrest. If the rhythm is shockable, the defibrillator must be immediately accessible and pads applied within seconds (Bircher et al., 2019; Italian Resuscitation Council, 2021; Soar et al., 2021; Thorén et al., 2020; Yow et al., 2025), despite the objective challenges of the surgical field, where patient positioning and surgical access may hinder high-quality CPR.

The proposed nursing care plan serves as a streamlined management tool, allowing nurses to standardize interventions for patients experiencing intraoperative SCA, which are subsequently evaluated based on the criteria established by the plan itself.

The use of the outcome "Cardiopulmonary Status (0414)" enabled a quantitative and objective evaluation of patient recovery. The sensitivity of the NOC indicators, measured via a 5-point Likert scale, proved effective in tracking hemodynamic fluctuations in real time. The progression of scores from 1 (Severe deviation) to 5 (No deviation) transcends mere numerical data; it represents a validated outcome measure documenting the effectiveness of nursing care. Research by Moorhead et al. (2020) confirms that NOC indicators are robust tools for measuring patient safety and the efficacy of mechanical ventilation during the post-resuscitation phase.

A notable strength of this work lies in its originality within the Italian scientific landscape. To date, there are no published case reports in Italy that have systematically and integrally employed the NANDA-I, NOC, and NIC taxonomies for the management of perioperative cardiac arrest. This study, therefore, serves as an innovative contribution aimed at filling a methodological gap in the nursing documentation of intraoperative emergencies within the national context. Such an approach moves beyond the simple description of technical maneuvers, instead highlighting clinical reasoning and the measurability of Nursing Sensitive Outcomes (NSOs).

Study Limitations

Despite the clinical relevance of this case, several methodological and operational limitations were identified:

- Deviation from Advanced ALS Protocols: first, it is noted that the "three shock

strategy" was not implemented. This approach is recommended by international guidelines for witnessed cardiac arrests with documented ventricular fibrillation in patients already under continuous monitoring (Al-Dury et al., 2017; Bircher et al., 2019; Haywood et al., 2018; Italian Resuscitation Council, 2021; Soar et al., 2021; Thorén et al., 2020; Yow et al., 2025).

- **Nature of the Case Report:** as this is a single case study within a specific perioperative setting, the findings describe an individual clinical progression. Therefore, the results cannot be statistically generalized to a broader population or different clinical contexts.
- **Subjectivity in Outcome Measurement (NOC):** although the Nursing Outcomes Classification provides a standardized framework, the assignment of scores on the 5-point Likert scale is partially influenced by the clinical judgment and expertise of the evaluating nurse. This element introduces a potential degree of inter-observer variability that could not be rigorously controlled in this study.
- **Training Gap and Simulation:** there was an absence of prior specific high fidelity simulation training within the operating room for crisis scenarios. Simulation based education remains a crucial investment to ensure team cohesion and patient safety during low frequency, high acuity events (Zanini, 2015).

In addition to the points raised above, it is necessary to emphasize that, according to Carpenito's Bifocal Model, the management of Sudden Cardiac Arrest falls within the domain of Collaborative Problems. In this context, the nurse does not operate with full diagnostic autonomy, as the event is a clinical complication requiring interdisciplinary management and prescriptive medical protocols.

The adoption of the nursing diagnosis "Risk for Compromised Cardiovascular Function (00311)" was not intended to define the cardiac arrest itself an event that falls outside the NANDA-I taxonomies as it is a medical diagnosis but rather served as a methodological tool to structure "proactive clinical surveillance."

The implementation of the NNN system allowed the "autonomous component" of nursing care to be rendered visible: while the

team managed the collaborative problem of the arrest, the taxonomic structure guided the nurse in monitoring premonitory signs, preventing recurrence and quantitatively evaluating the patient's functional recovery. This distinction is fundamental to understanding how standardized language does not limit nursing action to the mere execution of protocols but instead elevates it to a critical and documentable decision-making process.

Implications for Nursing Practice

Despite the identified limitations, this clinical case underscores the significant clinical utility of the NNN linkage in enhancing the safety and quality of perioperative care. The primary implication for practice lies in the capacity of standardized terminologies to operationalize complex clinical reasoning during life-threatening events. By providing a structured "common language", this framework bridges the communication gap between various surgical units, ensuring that critical patient data are not lost during clinical handoffs.

Furthermore, the systematic use of NOC indicators allows the clinical nurse to transform subjective observations into objective, measurable outcomes, thereby rendering the impact of nursing interventions "visible" to the entire multidisciplinary team. Finally, this model serves as a valuable tool for nursing education and simulation, training operating room nurses to transition seamlessly from the surveillance phase to active resuscitation within a scientifically validated methodological framework.

Conclusions

The effective management of an intraoperative SCA requires not only rapid technical proficiency but also a structured framework for clinical reasoning. This case report illustrates how the strategic integration of the NNN taxonomies provides a robust and comprehensive roadmap to guide nurses in managing high risk emergencies, both in the operating room and the PACU.

Through the application of this triple linkage, the nursing process transcends mere task-oriented interventions, operationalizing the nurse's complex cognitive workload and making

their unique contribution to patient survival measurable. The outcome indicators employed in this care plan reflected significant physiological stabilization of vital functions following the resuscitative phase, documenting the transition from severe clinical deviation to hemodynamic stability. This case demonstrates that a standardized nursing knowledge framework optimizes continuity of care and enhances decision-making during critical transitions.

In conclusion, this case represents one of the first contributions within the Italian context to document the efficacy of the NNN standardized language in managing critical intraoperative events. The originality of this methodological approach provides a benchmark for the standardization of advanced nursing care and for future research on nursing sensitive outcomes in Italy.

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Application of Virtual Reality in the Management of Preoperative Anxiety: A Systematic Review

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Abstract

Introduction. Preoperative anxiety, a common emotional response in patients awaiting surgery, is associated with adverse clinical outcomes, including postoperative complications and increased analgesic consumption. Although traditional anxiolytics are widely used, non-pharmacological approaches such as Virtual Reality (VR) are emerging as promising complementary strategies (Kallush et al., 2018). Thanks to its ability to create immersive environments, VR can reduce anxiety through mechanisms of distraction or familiarization with the surgical setting. To systematically assess the effectiveness of VR in reducing preoperative anxiety, with particular focus on clinical feasibility and the nursing role in its implementation.

Methods. A systematic review was conducted following the PRISMA guidelines, querying biomedical databases (PubMed, CINAHL, MEDLINE, Cochrane Library, Scopus, Science Direct) with MeSH terms and keywords. Fifteen studies (2019-2025) on adult patients undergoing elective surgery were included, excluding intraoperative applications or non-surgical contexts.

Results. Out of 1,507 participants, 11/15 studies demonstrated a significant reduction in preoperative anxiety with VR, especially in elective surgery. The most effective interventions varied based on the objective: 1) Procedural virtual tour (short duration) for anxiety. 2) Naturalistic environments with music for anxiety and pain. 3) Personalized 3D videos for active patient engagement.

Discussion. However, methodological heterogeneity and the lack of direct comparison with anxiolytics limit generalizability. VR is confirmed as a valid option for reducing preoperative anxiety, with potential economic (reduction in medication, operative times) and clinical (improved patient experience) benefits. Standardization of protocols, nursing training, and

the integration of multiple elements (e.g., 3D education + nature) represent future areas of development.

Keywords: Virtual Reality, Preoperative Anxiety, Perioperative Nursing, Preoperative Care, Patient Education

Introduction

Preoperative state anxiety constitutes a complex emotional response, characterized by apprehension, tension, and fear related to the imminence of surgery. This condition, often underestimated, not only compromises the patient's psychological well-being but is also associated with adverse clinical outcomes, including prolonged postoperative recovery, increased analgesic consumption, and a higher risk of complications. (Bandelow et al., 2017). Although traditional anxiolytics remain the most widespread therapeutic approach, recent literature highlights a growing interest in non-pharmacological strategies capable of acting synergistically with conventional therapies, reducing their side effects and enhancing their efficacy (Kallush et al., 2018).

Among the most promising innovations in the landscape of complementary therapies is virtual reality, an immersive technology that recreates simulated environments, allowing patients to experience progressive familiarization with the surgical setting.

In this scenario, the nursing figure emerges as a central actor in the perioperative care pathway. Through an empathetic and continuous relationship with the patient, the nurse not only provides clinical support but also becomes a key mediator in anxiety management, through communication strategies, reassurance, and preoperative education. (Dias et al., 2022; Xu et al. 2020).

The advent of virtual reality has its roots in the 1960s, with early pioneering experiments such as the Sensorama, a multisensory cinema booth, and the Telesphere Mask, the first wearable head-mounted display, which laid the foundations for an innovation destined to revolutionize many fields, including medicine. (<https://www.vr.org/about-us/history-of-vr/>)

Today, thanks to high-resolution VR headsets, haptic gloves, and sophisticated software, virtual reality has proven to be a useful tool in multiple applications, including: human simulation software, virtual robotic surgery, innovative

therapies for pain and psychological disorders, and also in nursing training during critical scenarios, improving decision-making readiness in high-stress situations. (Li et al., 2017).

Objective

This paper aims to systematically analyze the effectiveness of Virtual Reality (VR) interventions in the perioperative setting. The analysis is focused on the reduction of preoperative anxiety and specifically examines clinical feasibility and the nursing role in the implementation of such technologies.

Material and Methods

A systematic literature review was conducted, guided by the research question: "Can virtual reality alleviate preoperative anxiety in adults?" (research rationale).

The bibliographic search was carried out by consulting the main biomedical databases: PubMed (using MeSH terms and free-text keywords, with restriction to the Title/Abstract field to increase specificity), CINAHL, MEDLINE, Cochrane Library, and Science Direct. For the theoretical component, additional sources were examined, including Google Scholar and institutional academic resources.

To ensure a systematic and transparent review, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was adopted. Inclusion criteria prioritized recent research (2019–2025) on adult patients undergoing surgical procedures, the use of virtual reality (VR) exclusively in the preoperative phase, and studies with complete data and full-text access. Excluded were surgical interventions outside the operating room setting (such as in dentistry), VR applications during the intraoperative phase, gray literature, and reviews.

The selection process involved the following phases: initial screening, exclusion of non-relevant studies, and search results: by

combining the search strings, 549 articles were identified. Of the 470 full-text articles retrieved and assessed, 455 were excluded, for a total of 15 studies considered in the review.

Results

The overall sample consisted of 1,507 participants. Although no geographic restrictions were applied, most of the evidence came from studies conducted in: Belgium, the Netherlands,

Hong Kong, Singapore, South Korea, Brazil, China, Germany, Iran, Turkey, and Australia.

Characteristics of the included studies are summarized in Table 1.

In the included studies, the experimental group (treated with the device under investigation) was compared with: hypnotherapy, standard care/routine clinical practice, control group (no treatment), conventional instructions, and tablet-based viewing.

Participants underwent: cardiac procedures

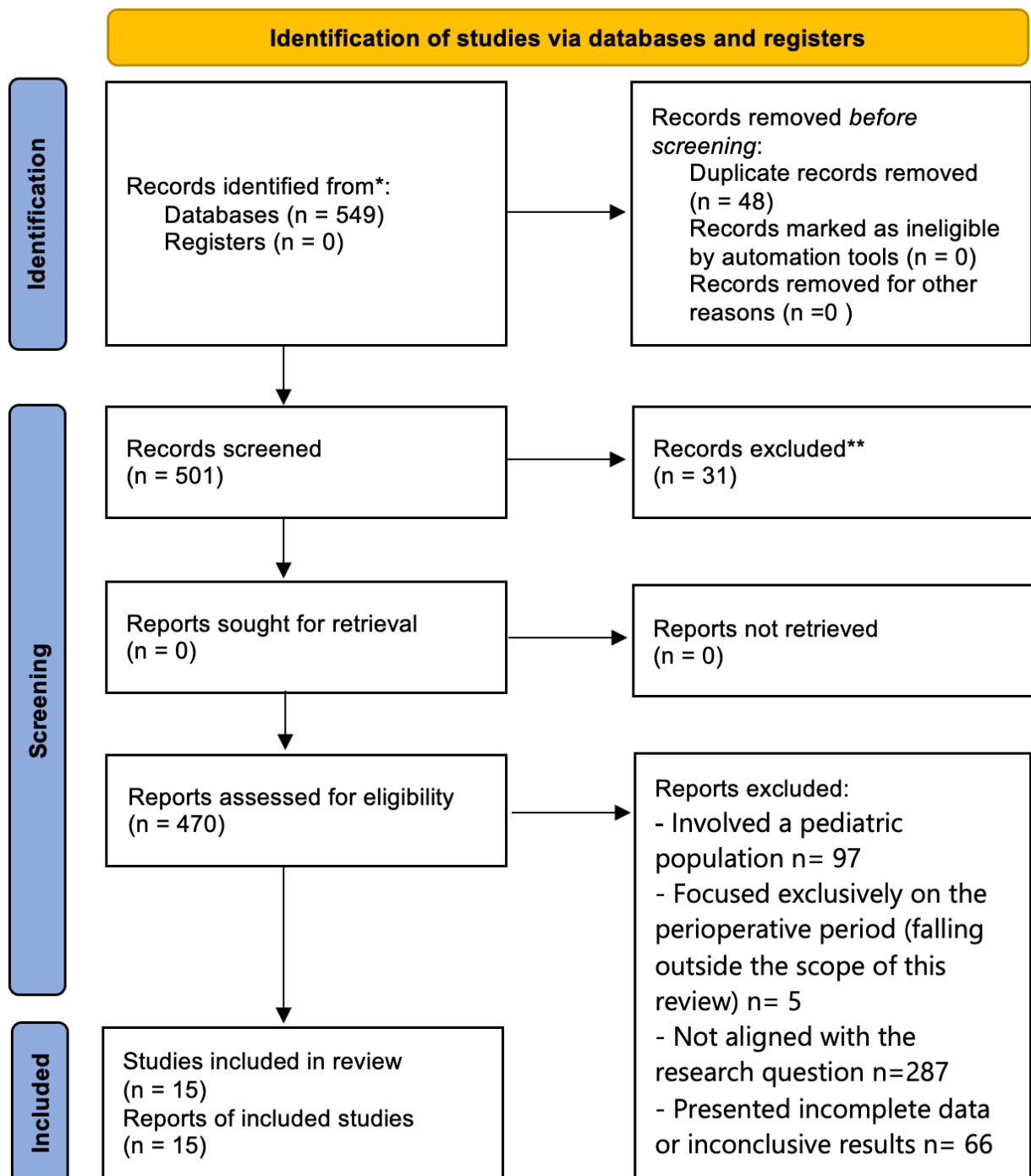


Figure 1. PRISMA 2020 flow diagram of study.

Table 1 (part 1). Characteristics, design, interventions, assessment tools, and main findings of the studies included in the review.

Autor/ Year	Setting/ Country	Design	Period	Role (participants and numbers)	Tools used	Goals	Principal results
1 Rosseaux et al. (2022)	Liege University Hospital, Belgium.	Prospective randomized controlled clinical trial.	October 2018 – January 2020.	A total of 100 patients (mean age 66; 24 women, 76 men) undergoing procedures such as coronary artery bypass grafting, mitral valve replacement, or multiple procedures were included.	Before and after each intervention, anxiety, pain, fatigue, and relaxation were assessed using the VAS scale (0–10), along with physiological parameters (heart rate, blood pressure, respiratory rate, pupil size, and oxygen saturation)	The primary objective was to evaluate the evolution of self-reported anxiety, pain, fatigue, and relaxation states in patients undergoing cardiac surgery, comparing the efficacy of hypnosis, virtual reality (VR), and a combination of the two (VRH) against a control group receiving standard care.	The study did not demonstrate an additional benefit of hypnosis, virtual reality, or their combination over standard care in improving postoperative anxiety, pain, or fatigue.
2 Chiu et al. (2023)	Pre-anesthetic evaluation clinic, Hong Kong	Prospective, randomized, blinded clinical trial	From July to December 2022	The study involved 74 participants aged 18 years or older awaiting their first elective surgery under general anesthesia.	Preoperative anxiety was measured using the APAIS scale. Secondary outcomes such as stress, preparedness, and pain were assessed using the VAS scale, as well as postoperative length of stay and satisfaction levels. Simulation sickness was evaluated using the Simulation Sickness Questionnaire.	The primary objective was to examine the efficacy of a virtual reality-based intervention with preoperative education in reducing preoperative anxiety compared to standard care.	The findings of this study indicate that a preoperative virtual reality-based intervention can effectively reduce anxiety and stress in patients awaiting elective surgery, while also improving their preparedness and satisfaction.
3 Chan et Al. (2020)	KK Women's and Children's Hospital, Singapore	Prospective cohort study	March 2019 – January 2020	108 patients undergoing elective minor gynecological surgeries.	Patients were assessed before and after the VR intervention using the HADS scale. Data on satisfaction and quality of life were also collected using the EuroQol 5 Dimensions 3-Level (EQ-5D-3L)	The study aimed to systematically evaluate the efficacy of two different virtual reality-based approaches in controlling preoperative anxiety, as well as their potential impact on reproductive outcomes.	The VR intervention demonstrated clinical efficacy, with a high level of patient satisfaction. The perceived improvement in discomfort and quality of life suggests a complementary role for VR in psychological preparation for surgery, especially for patients with high anxiety without the use of anxiolytic medications.
4 Pirard et al. (2025)	Cliniques universitaires Saint-Luc, Bruxelles	Double-blind randomized controlled clinical trial.	February 2017 – June 2019	The study involved 342 patients (aged between 18 and 42 years) candidates for medically assisted procreation techniques (IVF and ICSI).	Anxiety assessment was conducted using validated tools: the Visual Analogue Scale for anxiety (VAS) and the Spielberger State-Trait Anxiety Inventory (STAI).	The study aimed to systematically evaluate the efficacy of two different virtual reality-based approaches in controlling preoperative anxiety, as well as their potential impact on reproductive outcomes.	Although both VRD and VRH sessions before sedation in the operating room significantly reduced women's anxiety, the type of suggestions used during the VR hypnosis session did not influence the pregnancy rate.
5 Yang et Al. (2024)	Samsung Medical Center, Seoul	Open-label randomized controlled trial.	January 1, 2022 – February 28, 2023	88 patients with hepatocellular carcinoma (HCC) candidates for liver resection.	Anxiety was assessed using validated scales (STAI-X-1, STAI-X-2, and VAS) before and after the educational intervention, while knowledge of the procedure was measured using a specific questionnaire.	This study aimed to evaluate the impact of a virtual reality (VR) education program on anxiety and knowledge in patients with HCC undergoing liver resection.	The VR education program significantly improved knowledge and reduced anxiety among HCC patients compared to conventional methods.
6 Baytar et al. (2021)	Ecevit University Medicine Faculty Hospital, Zonguldak, Turchia	Prospective observational cohort study	October 1, 2020 – December 31, 2020	The study involved 40 adult patients (aged 18 to 65 years) with ASA physical status I-II.	Psychological parameters (STAI-S) as well as hemodynamic parameters were assessed before and after exposure to the virtual stimulus.	To evaluate the effects of an immersive virtual reality video on preoperative anxiety in patients candidates for elective septorhinoplasty.	This research confirms the potential of virtual reality as a complementary technique in preoperative preparation, particularly for elective surgical procedures.
7 Noben et al. (2019)	Máxima Medical Center, Netherlands	Randomized controlled trial.	November 2016 – January 2018.	It involved 80 women scheduled for elective cesarean section.	The primary outcome was the change in the Visual Analogue Scale for Anxiety (VAS-A) score upon admission. The Tilburg Pregnancy Distress Scale and the Childbirth Perception Scale were also administered.	This study aimed to evaluate whether a virtual reality video, added to standard preoperative information, could reduce anxiety levels before a scheduled cesarean delivery (CD).	The results showed no significant reduction in anxiety. However, in the subgroup of women with a previous emergency CD, a trend toward decreased anxiety emerged. 85% of women and 79% of partners in the VR group reported feeling more prepared after watching the video.
8 Aardoom et al. (2022)	Department of Cardiology, Leiden University Medical Center, Netherlands	Feasibility study.	January 6, 2020 – February 27, 2020.	The study involved 8 patients with a mean age of 67 years, awaiting elective cardiac catheterization	Presence Questionnaire and Immersive Tendencies Questionnaire for the degree of immersion; Client Satisfaction Questionnaire-8. To assess the usability of Pre- View, participants were asked to complete the System Usability Scale.	This study examined the efficacy of Pre-View, a reality app designed to guide patients through the entire cardiac catheterization pathway, with the aim of improving their psychological preparation.	In terms of perceived efficacy, all participants reported feeling better informed about the care process, with 88% stating that they felt better prepared for the procedure thanks to the app, and 75% acknowledging the potential of VR in reducing postoperative anxiety and stress.

Table 1 (part 2). Characteristics, design, interventions, assessment tools, and main findings of the studies included in the review.

Autor/ Year	Setting/ Country	Design	Period	Role (partecipants and numbers)	Tools used	Goals	Principal results
9 Vogt et al. (2021)	Department of Anesthesiology, RWTH Aachen University Hospital, Germany	Randomized controlled trial.	September 2020 – January 2021	84 patients undergoing elective surgery under general anesthesia.	The State-Trait Operation Anxiety (STOA) scale was used to assess perioperative state anxiety before and after the intervention. Additionally, user evaluations of VORT's usefulness were assessed with a rating questionnaire.	To examine the effect of a virtual operating room tour (VORT) on perioperative anxiety, comparing it with standard preparation (STOPP).	The results suggest that VORT, while not directly alleviating anxiety, addresses a need for clarity and preparation, critical elements for the patient experience. Patients rated the experience very positively, regardless of age or pre-existing anxiety level, suggesting that its value lies primarily in meeting the need for information and reducing uncertainty.
10 Liu et al. (2023)	Tertiary public hospital in Chengdu, China.	Single-blind, monocentric clinical trial.	November 2022 – February 2023	A total of 114 patients (aged 18–86 years) candidates for carotid artery stenting were enrolled."	The primary outcome, measured with the State Anxiety Inventory, was assessed before and after the intervention and at 24 hours post-intervention. Secondary outcomes included self-efficacy (SEMCD-6), sleep quality (monitored with a wristband), and satisfaction (VR Suitability and Satisfaction Questionnaire).	The study evaluated the efficacy of a virtual reality (VR) psychological intervention in reducing preoperative anxiety.	The use of a virtual reality psychological intervention was helpful in reducing patients' anxiety before CAS and improving their self-efficacy.
11 Bidgoli et al. (2023)	University- affiliated hospital in Kashan, Iran.	Prospective controlled observational study.	April to September 2022	105 individuals awaiting general surgery procedures.	It was administered a demographic questionnaire followed by the Spielberger State-Trait Anxiety Inventory. and the Mini-Mental Status Examination (MMSE), a cognitive screening test.	This study specifically focused on the comparative analysis between two different modalities of approach to the surgical environment – the traditional in-person one and the virtual reality-mediated one – comparing them with the standard preparation protocol.	Both familiarization modalities – physical and virtual – did not produce a statistically significant reduction in anxiety levels
12 Ugras et al. (2023)	General Surgery Unit of a university hospital in Mersin Province, Turkey.	Prospective, parallel, two- arm, randomized controlled trial.	June 2018 – May 2019	86 patients aged 18 to 65 years awaiting colorectal and abdominal wall surgery.	Anxiety was assessed using the ASSQ (Anxiety Specific to Surgery) questionnaire and by measuring physiological parameters.	To investigate the effects of a virtual reality (VR) application on preoperative anxiety (PA).	VR applications can effectively reduce both psychological and physiological responses to preoperative anxiety.
13 Mathari et al. (2024)	Department of Cardiothoracic Surgery, Amsterdam University Medical Center, Amsterdam, Netherlands.	Prospective, randomized, controlled, monocentric clinical trial.	April 2023 – July 2024	121 participants undergoing cardiac surgery.	Anxiety was measured using the STAI and APAIS, while satisfaction was assessed postoperatively through a customized questionnaire.	Evaluation of patient education on preoperative anxiety and satisfaction compared to traditional methods using virtual reality in cardiac surgery.	Although VR did not reduce preoperative anxiety, it significantly improved patient satisfaction; indeed, the experience proved effective in enhancing the perception of the information received, making it clearer and more engaging.
14 Schmid et al. (2024)	Gold Coast University Hospital (GCUH)	Monocentric, double-arm, single-blind randomized controlled clinical trial	May 2019 – December 2021	80 participants undergoing oncological gynecological surgery.	A novel six-level visual facial anxiety scale was used to assess preoperative fear, which correlated well with the Spielberger STAI questionnaire score. For the evaluation of secondary outcomes, specific patient characteristics were collected, such as age, type of procedure (laparotomy/laparoscopy/ other), and type of suspected tumor or anatomical site of the pathology.	The aim of this randomized controlled trial was to familiarize patients with the perioperative suite environment using VR technology and to assess whether this approach could reduce preoperative anxiety.	The results demonstrated that VR significantly reduced anxiety levels, both immediately after the intervention and in the period preceding surgery. In the VR group, the median anxiety score decreased from 3 to 2, while in the control group it remained stable at 4.
15 Hooglugt et al. (2022)	Amsterdam University Medical Center, Paesi Bassi.	Prospective, monocentric, randomized controlled trial	March 2019 – October 2020.	60 patients undergoing percutaneous closure of PFO or ASD.	The primary outcome was the change in pre- procedural anxiety, assessed using the STAI and APAIS questionnaires, completed during the outpatient visit (baseline) and one week before the procedure (follow-up).	This study was conducted to evaluate the effect of Virtual Reality (VR) as a means to educate patients in reducing pre-procedural anxiety in adult patients undergoing percutaneous closure of a patent foramen ovale (PFO) or atrial septal defect (ASD).	During follow-up, anxiety increased in the control group but remained unchanged in the intervention group. Patient education using virtual reality is effective in reducing pre-procedural anxiety in patients undergoing percutaneous closure of PFO or ASD.

(surgery, PFO/ASD closure, and catheterization), gynecological interventions (minor surgery, oocyte retrieval, cesarean section, oncology), general surgery (hepatocellular carcinoma, colorectal and abdominal wall procedures), septorhinoplasty, and carotid artery stenting.

In 11 out of 15 studies, the effectiveness of the intervention in reducing preoperative anxiety was demonstrated, especially in elective surgical settings. Assessments were conducted using validated scales, which allowed for the objectification of clinical parameters such as anxiety and perioperative pain.

The results show heterogeneous efficacy: while some studies demonstrate a significant reduction in anxiety, others report null outcomes, often due to methodological biases (e.g., non-representative samples) or a lack of standardization in VR scenarios. Several authors emphasize the need for further evidence to consolidate the findings.

Discussion

Virtual reality has proven to be a promising tool in the management of preoperative anxiety, although its efficacy varies depending on the clinical context, type of intervention, and patient characteristics. The studies analyzed reveal conflicting results, suggesting that VR is not a one-size-fits-all solution but rather a technology whose success depends on proper implementation and personalization.

This concluding section critically analyzes the emerging data, focusing on five main outcomes that emerged.

Actual effectiveness in reducing preoperative anxiety

The intervention proved effective in reducing anxiety in 11 out of 15 studies, particularly in elective surgical settings. In the study by Chiu et al. (2023), concerning elective surgery, a 30% reduction in APAIS scores was recorded ($p < 0.001$). In the study by Chan et al. (2020), in the gynecological setting, a decrease in anxiety scores on the HADS scale was observed, from 7.2 to 4.6 ($p < 0.0001$). However, some studies did not find significant benefits compared to standard care. This is the case with the studies by Rosseaux et al. (2022) (cardiac surgery) and Noben et al. (2019) (cesarean section), which

found no additional benefits over standard care; Mathari et al. (2024) (cardiac surgery) and Bidgoli et al. (2023) (physical/virtual tour) showed no significant differences.

Why do some studies fail? Populations with complex needs: patients in high-stress settings (e.g., cardiac surgery or cesarean section) may derive less benefit from non-pharmacological tools compared to other groups. Rosseaux et al. (2022) specified that VR in cardiac surgery is not sufficient to overcome postoperative physical stress. Bidgoli et al. (2023) argued that familiarization with the operating room (physical or virtual) does not modify anxiety unless accompanied by psychological support.

Content and patient experience

Users involved in the studies experienced different types of virtual environments, classified into two macro-categories:

- **Relaxing/natural environments:** relaxing landscapes such as beaches, forests, mountains with music and breathing techniques (Chan et al. 2020), immersive videos of oceans and nature (Baytar et al. 2021), virtual walks on the beach or in the woods (Ugras et al. 2023). These scenarios primarily act as a distraction, reducing anxiety through sensory relaxation.
- **Medical-surgical environments:** operating room tours with procedural explanations (Chiu et al. 2023), interactive 3D liver models for preoperative education (Yang et al. 2024), virtual pathway related to cardiac catheterization without the procedure (Aardoom et al. 2022). These approaches aim to reduce uncertainty by improving patient preparation through gradual exposure.

Differences: Natural environments are more effective for patients with generalized anxiety (Chan et al. 2020). Procedural tours work better when anxiety is related to lack of information (Liu et al. 2023).

Mechanisms influencing the effect of VR

- **Duration:** Short sessions (5–10 min) are sufficient for distraction (Noben et al. 2019); long sessions (15–20 min) are necessary for education (Pirard et al. 2025).
- **Interactivity:** VR with active interaction increases engagement (the user is involved; an

example was the quiz during VR in Aardoom et al. 2022); passive VR (such as 360° videos) is less effective in reducing anxiety in the long term (Bidgoli et al. 2023).

- **Target population:**

- Patients with high anxiety (STAI-T > 40) benefit more from VR (Liu et al. 2023, Chan et al. 2020) compared to those at low risk (Rosseaux et al. 2022).

- Women show higher anxiety (Mathari et al. 2024 and Schmid et al. 2024 report that women show significantly higher levels of preoperative anxiety than men, even after VR interventions).

- Age: elderly patients are less receptive (Yang et al. 2024 excludes >70 years due to risk of motion sickness); they may require low-immersion content such as 2D videos with clear audio, avoiding rapid movements; furthermore, one could focus on family members/caregivers, involving them in the VR experience (Hooglugt et al. 2022: partner watching the video together). Young patients and ASA I respond better (Chiu et al. 2023).

- Surgical context: elective vs. urgent surgery: VR is more effective in planned procedures (Chiu et al. 2023 vs. Rosseaux et al. 2022) and procedure complexity: oncology patients (Schmid et al. 2024) or cardiac patients (Hooglugt et al. 2022) benefit more from virtual preparation.

- Optimal settings identified: preoperative area (Chiu et al. 2023), waiting room (Chan et al. 2020), home setting (Aardoom et al. 2022).

Impact on clinical outcomes (pain, satisfaction, stress)

Impact on pre- and postoperative pain

Although VR has been studied primarily for preoperative anxiety, several of the analyzed studies evaluate its impact on pain (also assessing analgesic medication consumption), with conflicting but promising results.

Regarding preoperative pain, an indirect reduction emerged. In the study by Chan et al. (2020) on gynecological surgery, VR improved the subjective perception of pain (measured with the VAS scale) through anxiety reduction; lower dosages of postoperative NSAIDs and opioids were also recorded, although these data were not statistically significant. Similarly, in Ugras et al.

(2023), VR normalized physiological parameters such as reduced heart rate and increased oxygen saturation, suggesting an effect on the autonomic nervous system that may modulate pain sensitivity. This translated into a reduced need for additional analgesic medications in correlation with stress reduction.

Regarding postoperative pain, the results are mixed. On one hand, no direct effect was found: Rosseaux et al. (2022) in cardiac surgery showed no differences in morphine use, other analgesics, or postoperative pain between the VR group and the control group, and Chiu et al. (2023) demonstrated that VR did not influence postoperative analgesic consumption. On the other hand, indirect positive effects also emerged: Ugras et al. (2023) showed a reduction in postoperative blood pressure and heart rate, markers of reduced pain-related stress. Furthermore, Liu et al. (2023) in carotid stenting found an improvement in self-efficacy (SEMCD-6) in the VR group, which may translate into better pain management; in the same study, the measurement of tramadol use in the first 24 hours revealed a trend toward lower use in the VR group (-15%, $p=0.07$).

Increased satisfaction in all articles

Why is it important? VR as a patient engagement tool: increasing satisfaction can improve adherence to care (postoperative follow-up).

Why does VR increase satisfaction?

- Improved perception of care: Virtual operating room tours reduce uncertainty, giving patients a sense of control over the process. In the study by Yang et al. (2024), patients appreciated the 3D visualization of their own liver, perceiving greater personalization of care, while in the study by Noben et al. (2019) (cesarean section), VR did not reduce anxiety, but 85% of women felt "more prepared."

Furthermore, VR demystifies complex procedures (e.g., cardiac catheterization in Aardoom et al. 2022), increasing trust in the healthcare team. Finally, the time spent in VR is interpreted as additional care (Schmid et al. 2024: patients report feeling "more listened to").

Although in the analysis by Bidgoli et al. (2023), satisfaction was also high in the group with a physical operating room tour, suggesting that the attention provided by nurses (not just the time spent using the device) matters.

- Technological novelty: The use of VR headsets is perceived as innovative and reassuring. In the study by Mathari et al. (2024), 91% of patients rated the experience as "excellent," and in Chan et al. (2020), 82% of patients defined VR as "fun" or "relaxing," despite the invasive procedure.
- Reduction of hospital stigma: Natural environments in VR create a positive association with the clinical setting (Baytar et al. 2021).

Reduction of preoperative stress.

Only 1/3 of the studies, i.e., 5 out of 15, explicitly measured stress, but positive results nonetheless emerged: Chiu et al. (2023) observed a marked decrease in perceived stress (-10.68 points on the VAS scale) with effects lasting up to the time of surgery. Ugras et al. (2023) recorded objective improvements: heart rate, blood pressure, and oxygen saturation stabilized after only 10 minutes of VR with natural environments. Liu et al. (2023) highlighted how VR combines stress reduction and increased self-efficacy, suggesting a dual mechanism of action (distraction + empowerment).

Nurse education on the use of VR in the preoperative setting

Training nursing staff in the use of virtual reality emerges as a critical factor for the effective implementation of these protocols, although few studies systematically address this aspect. From the review of the analyzed articles, two key points emerge:

1. Need for specific training: Several studies emphasize that the nurses involved in the studies received dedicated training sessions.
- Chiu et al. (2023): nurses were trained for 30 minutes on how to configure the headsets, adjust interpupillary distance, and manage technical issues.
 - Aardoom et al. (2022): staff were trained to use the Pre-view app for cardiac catheterization, with a focus on interaction with elderly patients.
 - Schmid et al. (2024): a standardized procedure was created to ensure correct VR administration in gynecological oncology.

- In Noben et al. (2019), nurses played a key role in reassuring women during the VR tour of cesarean section, demonstrating that communication skills are as important as technical ones.
- In Ugras et al. (2023), the lack of a standardized protocol led to differences in VR application among nurses, with possible effects on outcomes.

However, no study evaluated the impact of different levels of training on patient outcomes, and there was no standardization: each study adopted ad hoc training protocols that are not replicable.

Required skills: Technical: device configuration, troubleshooting (e.g., headset calibration). Psychological support: guiding patients through the VR experience, especially in cases of high anxiety or discomfort. Hygiene: management of disposable covers and device disinfection (a critical issue emerged in Chiu et al. 2023 and Liu et al. 2023).

In summary, nurse education on VR is fundamental but underestimated in the literature. Structured training (technical + psychological), evaluation of the impact of nursing skills on outcomes, and standardized guidelines to ensure uniformity are needed.

Study limitations

Self-assessment bias (use of subjective scales without physiological markers such as cortisol or heart rate in many studies), non-representative samples with limited generalizability, lack of standardization, and no study directly comparing VR with anxiolytics (although Chan et al. 2020 suggests a complementary role).

Why invest in virtual reality in the medical-surgical setting? This represents a strategic choice that combines therapeutic innovation with healthcare sustainability, acting on three main fronts: patient well-being, clinical efficiency, and cost reduction.

The starting point is the management of preoperative anxiety, which affects a significant percentage of patients, increasing the risk of complications such as hypertension and postoperative nausea, and consequently prolonging recovery times. VR presents itself as a non-pharmacological solution, demonstrating in clinical studies an efficacy comparable to

midazolam but without its systemic side effects. The adoption of VR can lead to a reduction in the use of anxiolytics, generating a positive chain reaction: calmer patients at the time of anesthetic induction translate into fewer delays in the operating room, faster turnover, and significantly greater patient satisfaction.

A second pillar is the reduction of acute pain and opioid consumption. The opioid dependence crisis makes the search for effective alternatives crucial. VR, acting through a powerful immersive distraction mechanism, can reduce pain perception by 20–50%, consequently decreasing the demand for potent analgesics. Lower opioid use means not only a better safety profile for the patient, with reduced adverse effects such as nausea and constipation, but also lower direct costs for medications and potentially shorter hospital stays.

The model is also sustainable from an economic perspective. A cost-benefit analysis estimates that the initial investment for a medical-grade headset and dedicated software could pay for itself within 1–2 years. Savings derive from multiple sources: reduced use of anxiolytic and analgesic medications, a 10% reduction in operating room time allowing for more procedures to be performed, and a decrease in costly postoperative complications, with a reduction in readmissions. Therefore, VR is not a cost but an investment that self-finances through improved clinical efficiency. It is appropriate to add that the final economic outcome depends on the organizational ability to implement it efficiently and on a large scale.

Conclusions

The most effective virtual reality intervention appears to depend on the specific objective to be achieved. When the primary goal is to reduce preoperative anxiety, a short procedural virtual tour may represent the most appropriate approach, whereas naturalistic videos combined with music or other auditory stimulation may be more suitable when the aim also includes reducing perceived pain. Personalized three-dimensional content may instead offer greater potential for actively engaging patients in their care. None of the studies included in this review evaluated an integrated protocol combining procedural tours, natural environments, and personalized 3D educational content, suggesting

a relevant area for future investigation.

Several limitations should be considered when interpreting the available evidence, including the frequent use of subjective self-assessment scales without complementary physiological measures, non-representative samples, limited generalizability, substantial heterogeneity among VR interventions, and the absence of direct comparisons between VR and pharmacological anxiolytic strategies. Nevertheless, the findings suggest that virtual reality may represent a promising non-pharmacological approach to the management of preoperative anxiety, with potential benefits for patient experience, perioperative pain, stress, satisfaction, and engagement. Its implementation may also contribute to reducing reliance on anxiolytic and analgesic medications and improving organizational efficiency, although the economic sustainability of VR programs depends on local workflows, implementation strategies, equipment costs, and the ability of healthcare organizations to integrate the technology effectively into routine practice.

Future research should therefore focus on longitudinal evaluation of postoperative recovery and medication use, personalization of VR content according to individual psychological characteristics, and the development of standardized protocols defining the duration, content, timing, and clinical indications of VR interventions. Emerging technologies such as biofeedback, generative artificial intelligence, and mixed reality may further increase personalization and interactivity by allowing virtual environments to respond dynamically to physiological parameters and patient behavior. Overall, moving from isolated experimental applications toward structured and reproducible perioperative VR pathways will require further clinical evidence, standardized implementation models, and appropriate professional training.

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Dr Potts' Blue Children

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Abstract

This narrative article aims to explore the life of Willis John Potts, a surgeon and pioneer in the field of pediatric cardiovascular surgery. Between the 1950s and 1960s, his work contributed enormously to the development of new surgical techniques and instruments; nevertheless, he remains a largely forgotten figure. Yet his determination and organizational skills enabled rapid and fundamental advances in surgery. Historical research, utilizing biomedical databases, represents an attempt to do historical justice to Potts: although unusual, this methodology has yielded a wealth of indexed information on Potts, including publications by him and his key collaborators. An analysis of Potts' surgical career is also an analysis of the development of both pediatric surgery and, above all, cardiac surgery: the instruments and procedures he devised have found applications well beyond the exclusively pediatric field.

Keywords: Willis John Potts, History of Surgery, Pediatric Surgery, Cardiovascular Surgery, Surgical Instruments, Congenital Heart Disease

Wisconsin to Pediatric Surgery

Potts' scissors are one of the most widely used microsurgical scissors in operating theatres; from plastic surgery to cardiac surgery, and across thoracic and vascular disciplines, they are an indispensable tool for managing blood vessels. Yet the story of the man who invented them is unknown to most people today. Willis John Potts was born in Sheboygan County, Wisconsin, in 1895, into a Unitarian Christian family; his faith always played an important role in his life, inspiring him to devote himself to children. The Potts family owned a farm near Cedar Grove; on his father's death, Willis had to run the farm alongside his elder brother but managed to save enough money to enroll at a private school, obtaining a diploma that

subsequently enabled him to attend college. In 1917, when the United States entered the First World War, Potts enlisted in the army and spent a year on the French front (Baffes, 1987). In 1919, upon his return from Europe, Potts enrolled at Rush Medical School in Chicago, where he graduated with a degree in medicine in 1924, before practicing briefly in Oak Park, on the outskirts of the city. The very next year, he decided that surgery was his field of interest; consequently, he attended the Presbyterian Hospital, where he qualified in 1928. To complete his surgical training, Potts spent the period 1930–1931 undertaking postgraduate training in Frankfurt am Main, from which he returned having learnt much from the German school of surgery; upon his return to the United States, he settled in the Chicago suburbs, where he practiced as a

surgeon until 1940 (Baffes, 1987; Riker, 1968). The war once again disrupted his life on 7 December 1941, with the Japanese attack on Pearl Harbour. In the wake of the US national mobilization, some of the medical and nursing staff from West Suburban Hospital in Chicago volunteered to form the 25th Evacuation Hospital: among them was our very own Potts (Baffes, 1987). After a period of training and preparation, the medical unit of the 25th Evacuation Hospital, with its complement of personnel and equipment, reached the South Pacific theatre of war by ship in November 1942, arriving at Port Vila, before continuing further north to the island of Espiritu Santo. 1,000 km to the north-west the bloody and fierce campaign of Guadalcanal was underway, and surgeons and nurses were needed to treat the marines fighting there. Given the proximity of the 25th Evacuation Hospital's destination to the bases of the Imperial Japanese Navy, and fearing air raids, the ship carrying the medical equipment remained at Port Vila: the personnel sent to Espiritu Santo had to 'make do' with the buildings, facilities, furniture and shelving available, and physically construct the military hospital themselves, with the help of scarce medical supplies provided by the US Navy. After months of work in the stifling jungle, with the help of soldiers and local inhabitants, the staff managed to complete the facility, which had a capacity of 750 beds (South Pacific WWII Museum, n.d.). During the war years, Potts was promoted to the rank of colonel in recognition of his organizational skills and surgical expertise. In 1945, towards the end of the war, he came across a book that would prove pivotal to his life: *Abdominal Surgery of Infants and Childhood*, published by Gross and Ladd in 1941 (Baffes, 1987). He was so captivated by the nascent field of pediatric surgery that he decided that would be his path (Baffes, 1987). Pediatric surgery as an independent and autonomous branch was in its infancy, having emerged only once reliable knowledge, expertise and techniques for the care of children had become available. The prevailing practice was still to admit young patients to surgical wards alongside adults, as, according to some "...surgical conditions should be treated in major hospitals" (Hazeltine & Hirsh, 2022). The first pediatric surgical ward was established at the Royal Edinburgh Hospital for Sick Children in 1887. Even in

the early years of the 20th century, there were no specialist training programs in pediatric surgery, although there was pressure for children to receive dedicated surgical care. It was the years immediately following the Great War that brought about change, particularly in the Anglo-Saxon world, thanks to the work of William E. Ladd (1880–1967), who, deeply moved by the children involved in the Halifax explosion of 1917, decided to devote himself entirely to them at the Children's Hospital in Boston, where he dedicated himself to treating numerous conditions such as biliary atresia and obstruction, pyloric stenosis and other intestinal malformations (Hazeltine & Hirsh, 2022). His work earned him the title of Surgeon-in-Chief at Boston Children's Hospital in 1941, whilst he was also launching the first specialization course in Pediatric Surgery; and it is precise here that our Dr Potts comes into the story.



Figure 1. Willis John Potts (1895–1968).

The “Blue Children” and the Potts Anastomosis

Upon his discharge from military service

in 1945, Potts returned to Chicago, where he secured a post at the Children's Memorial Hospital (Baffes, 1987); at the time, the hospital mainly performed laparotomies, appendectomies and pyloromyotomies, but Potts, having read the section on congenital heart disease in Gross and Ladd's textbook, was determined to embark on something new: to establish a pediatric surgical training program focused on cardiac and vascular defects. The following year, he was also appointed to the post of Professor of Surgery at Northwestern Medical School (now the Feinberg School of Medicine at Northwestern University) (Baffes, 1987; Riker, 1968). Potts's idea at this point was to establish a surgical residency training program based on the best available knowledge and techniques, with a focus on vascular techniques in pediatric patients. But how could he achieve all this, given that at the time this field of interest was completely unknown and groundbreaking? First, Potts spent three months at Boston Children's Hospital to learn about its organization; he studied its structure, which was divided into specialist departments, and, upon returning to Chicago, set about putting his plans into action (Baffes, 1987; Riker, 1968). First and foremost, expertise and professionals were needed: therefore, thanks to his connections and his character, Potts attracted many experts such as orthopedic surgeons, anesthetists, urologists, abdominal surgeons and plastic surgeons. However, to establish an advanced and modern pediatric surgery program, research facilities were also required; Potts insisted on—and succeeded in—converting part of the pediatric hospital's infectious diseases ward into a research laboratory, equipped with a sterile operating theatre and an animal facility (Baffes, 1987). To tackle the challenge of major vessel surgery, Potts had to consider building his own team of collaborators; upon his return to Chicago in 1945, he had already met Stanley Gibson, a nationally renowned pediatric cardiologist famed for his diagnostic skills, to whom was added Joseph Boggs, Director of the Pathology Department and a leading expert on congenital heart defects (Baffes, 1987). Thanks to his collaboration with Gibson and Boggs, a program for the diagnosis and treatment of congenital heart disease in children was launched. From among the young surgeons working with him, Potts chose

Sidney Smith as his most trusted colleague: his skill at performing vascular anastomoses and in devising new approaches to surgical challenges had made him indispensable. To give an idea of the enthusiasm and passion Potts poured into his project, just over a year had passed since his arrival at Chicago Children's Memorial Hospital (Baffes, 1987). It is also important to understand the context and scope of the projects Potts aspired to: in 1946–1947, cardiovascular surgery on pediatric patients was at the very limits of what was feasible. In those years, the only procedure made possible was the correction of tetralogy of Fallot, also known as 'blue baby syndrome' due to its cyanotic nature; the clinical-pathological profile of this malformation, supported by specific diagnostic tests, had been presented by the American cardiologist Maude Abbot as recently as 1936, and in 1945 Alfred Blalock, at the suggestion of his colleague, the cardiologist Helen Taussing, introduced a surgical procedure to alleviate the anoxia caused by pulmonary stenosis or pulmonary atresia through an anastomosis between the subclavian or anonymous artery and the right or left pulmonary artery (Dionigi, 2017, p. 956). While finalizing the organization of his surgical department, Potts kept himself constantly up to date and, together with his team, devised a different approach to correcting blue baby syndrome.

On Friday 13 September 1946, Potts's team performed the first operation to correct Tetralogy of Fallot on a young girl, Diane Schnell, by creating an aorto-pulmonary anastomosis. Technically, the procedure was less complex than the one developed by Blalock in Baltimore, which involved transection of the right subclavian artery and anastomosis onto the right pulmonary artery (Dionigi, 2017, p. 956), but it required direct manipulation of the large vessels, with the descending thoracic aorta clamped for the time necessary to perform the anastomosis (Potts et al., 1946): the risk of spinal cord injury and ischemia, leading to paraplegia, was very real. The young patient survived the operation and was discharged from hospital 19 days later (Baffes, 1987; Riker, 1968). Two factors had made Potts's operation possible; firstly, the technique had been simulated and perfected at the research laboratory of the Children's Memorial Hospital in Chicago: Potts's team

practiced the anastomotic technique on several dogs (Baffes, 1987). But above all, Potts had an ace up his sleeve: a surgical instrument specially made by his neighbor; whilst living in Oak Park, Willis Potts lived next door to Bruno Richter, a talented craftsman who designed and manufactured surgical instruments for a local medical supplies company (Baffes, 1987). Needing to find a solution that would allow adequate blood flow to the medullary arteries, Potts, his colleague Smith and Richter set to work in the summer of 1946 to find a solution. Richter found the solution by modifying an eyelid retractor: the resulting instrument allowed blood flow to the lower part of the body whilst 'isolating' the area affected by the suture; several versions of this hemostat were produced, in various sizes to better suit the different calibers of the vessels (Potts et al., 1946; Zeller et al., 2022).

Instruments That Changed Surgery

Richter's contribution was not an isolated case; in 1947, Potts read about the operation performed by Robert Edward Gross, a surgeon at Boston Children's Hospital, to close the ductus arteriosus (Gross, 1947). This vascular malformation, which connects the left pulmonary artery or the pulmonary trunk to the descending thoracic aorta, is quite common in premature or low-birth-weight infants, in whom it can lead to a critical clinical condition (Dionigi, 2017, p. 948); its correction by ligation had already been attempted in 1938 (again by Gross himself), but the 1947 procedure involved the use of delicate clamps (such as Mosquito clamps) to clamp the two vascular ends of the ductus, followed by its transection and the subsequent placement of terminal sutures on the two vascular stumps. Potts soon recognized a problem: the use of surgical instruments designed for adult patients on the cardiovascular tissue of a pediatric patient exposed the latter to numerous risks, both in terms of the reliability of vascular clamping and the potential for tissue damage. After giving it some thought, he once again turned to his neighbor for help: together with Richter, they devised a new class of instruments, the vascular clamps (Baffes, 1987; Moritz et al., 2022; Potts, 1948) (Fig.2). Characterized by a bite with a longitudinal groove capable of

sealing the vessel wall without damaging it, the idea came to Potts whilst he was casually observing the packaging of an elastic bandage, and Richter skillfully designed and then constructed the vascular clamp (Baffes, 1987). Following the usual experimental work on dogs, Potts used the clamp he had devised with Richter on his patients: 16 children aged between 2 and 13, in whom the ductus was dissected and subsequently sutured, with no deaths or post-operative complications. These instruments heralded a new era in large vessel surgery (Potts, 1948).

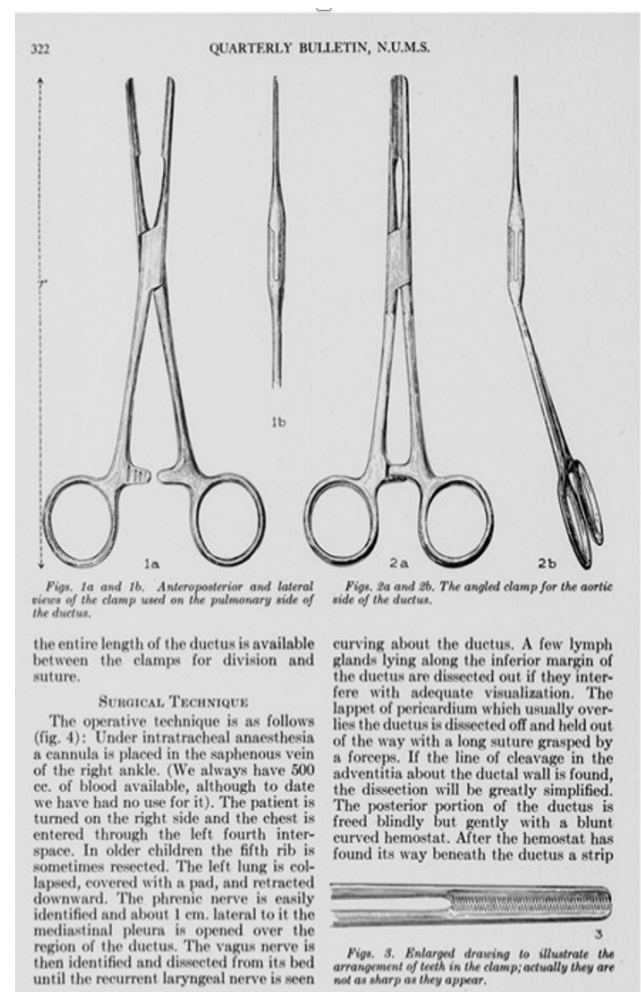


Figure 2. Original illustration of the vascular clamp developed by Willis J. Potts and Bruno Richter.

Potts, specializing in the field of large vessels, made a significant contribution to the technique of vascular anastomosis. At the time, the preparation of arterial sutures was still considered a limitation: the only method available was the application of venous

grafts to arterial trunks, which considerably restricted both the scope of application and the technical options (Moritz et al., 2022). Potts devised numerous instruments to facilitate surgery on arterial trunks: during those years, he commissioned the craftsman Richter to produce many surgical instruments. First and foremost were his famous vascular dissection scissors, with angles of 25°, 45°, 60° and 90°, designed for high-precision cutting and dissection of blood vessels (Fig. 3). He also had thin, delicate surgical forceps made, capable of gently holding arterial tissue without damaging it; the use of vascular clamps designed for the safe occlusion of arterial segments also revolutionized vascular surgery. Potts, with the help of his trusted colleague Richter and his collaborators, devised surgical instruments that are still in daily use in operating theatres today (Baffes, 1987).



Figure 3. Potts vascular dissection scissors.

In the fields of vascular surgery and cardiac surgery, Potts also turned his attention to adult patients, developing (again in collaboration with Richter) the valvulotome. By the first half of the 1950s, cardiac surgery was booming: numerous centers of excellence were emerging, such as those in Toronto and Montreal, the Karolinska Hospital in Stockholm, Guy's Hospital in London and the Ospedale S. Giovanni Battista in Turin (Actis Dato & Actis Dato, 2020; Castañeda, 2005). It was precisely thanks to the concurrent work of Charles Bailey, Dwight Harken, Russell Brock and Achille Mario Dogliotti that closed-heart mitral commissurotomy was introduced during

those years (Actis Dato & Actis Dato, 2020). In 1952, Brock described his pioneering work on transventricular pulmonary valvulotomy (Brock, 1952); this was a closed-heart surgical procedure to correct pulmonary valve stenosis. In this case too, Potts carefully studied the work of his London-based colleague and considered that the procedure performed by Brock was very interesting, but that the profuse bleeding—linked to the opening of the heart chamber to allow the retractor to enter—was incompatible with patient safety. Potts and the expert Richter then devised a specialized instrument: the valvulotome. Fitted with retractable blades whose opening could be adjusted via a selector switch in the handle, the instrument was inserted through a small external incision in the right ventricle; guided by the tactile sensation of his fingers, the surgeon inserted the tip of the valvulotome through the pulmonary valve and ‘incised’ the valve itself with the retractable blades. Once the procedure was complete, the instrument was withdrawn and the small access point on the ventricular wall closed: a potentially dangerous procedure which, thanks to Potts and Richter, was transformed into something relatively simple (Baffes, 1987; Glenn, 1987).

Innovation in Congenital Heart Surgery

Between 1954 and 1955, Willis Potts took an interest in the work of Alfred Blalock and Rollins Hanson at Johns Hopkins University: the surgical correction of transposition of the great arteries (TGA). This condition is a cyanotic congenital heart defect, characterized by atrioventricular concordance and ventriculo-arterial discordance, with the aorta arising from the right ventricle and the pulmonary artery originating from the left ventricle. The resulting clinical condition is clearly serious and, in cases associated with additional heart defects, becomes incompatible with survival in the medium term (Dionigi, 2017, p. 960). The two surgeons at Johns Hopkins had been working on this since 1948, when they proposed the creation of a ‘site’ for the mixing of arterial and venous blood: after studying 123 cases of TGV, they hypothesized the use of a surgically created atrial septal defect to allow oxygenated blood to pass into the systemic circulation (Marathe & Talwar,

2015). In 1950, the two surgeons succeeded in performing this technique – the Blalock-Hanlon septectomy – on a patient; although regarded at the time as a surgical feat, the procedure was nevertheless considered a palliative measure as it did not definitively resolve the malformation (Marathe & Talwar, 2015). Shortly afterwards, in September 1953, Walton Lillehei and Richard Varco reported on eight surgical attempts they had made to correct TGV (Glenn, 1987): in the first four operations, the surgeons had anastomosed the right pulmonary veins to the right atrium (only two out of four patients survived), whilst in the following four patients they had performed an anastomosis of the inferior vena cava to the left atrium (none of these patients survived). This is precisely where our protagonist comes in: it was 1954 and Thomas Buffes, a young trainee on Potts's course, proposed his own idea for the surgical correction of TGA (Baffes, 1987). The young surgeon's idea was to perform a venous correction using an aortic graft to bypass the inferior vena cava to the left atrium. Buffes himself recounted: "When I first presented the idea of designing a partial venous correction for transposition of the great arteries to Dr Potts, he curled his moustache, as was his habit, and fell into deep thought. After a while, he said: 'Transposition accounts for about half of the defects in cyanotic children admitted to this hospital. We haven't been able to do much for any of them, except for those special cases with pulmonary stenosis and ventricular septal defects.' He thought for a little longer; then his eyes sparkled with excitement. 'Go on, do it!' 'I shall provide the necessary funds.' And so began many happy years of research and discovery under the guidance of the master surgeon" (Baffes, 1987). There were numerous obstacles to overcome, and not just surgical ones: what material should be used to create the bypass envisaged by Buffet's idea? The technology for grafts using Dacron or polytetrafluoroethylene (PTFE) prostheses was still in its infancy: it was not until 1952 that Voorhees and his colleagues at Columbia University had used tubular polyvinyl chloride grafts in animal models, with results deemed contradictory (Lillehei & Varco, 1953). As no other materials were available, it was decided to use human aortic tissue: under Potts' supervision, Buffett and his colleagues began to develop a method for harvesting, sterilizing and preserving human

aortic homograft, which were freeze-dried and vacuum-packed; only once this initial difficulty had been overcome was it decided to move on to the second stage: studying the use of aortic tissue and any possible complications or difficulties in animal models. To achieve this, species-specific aortic homografts were created and used to bypass the inferior vena cava in several puppy dogs; the team then waited for the dogs to reach full maturity to check that there were no signs of obstruction or tissue damage. Given the very promising results, Potts decided that the procedure could be attempted on a select group of patients: on 6 May 1955, the operation was performed with a successful outcome and was published the following year in an article which, strangely, listed only Baffes as the author (Baffes, 1956). By 1960, a retrospective study had been published – again authored by Baffes but with Potts among the co-authors – to illustrate the 5-year survival rate following the introduction of the technique he had devised, which had stood at 29 per cent out of 117 cases treated (Baffes et al., 1960). The procedure devised in collaboration with Potts remained the treatment of choice for newborns with transposition of the great vessels for the following 10 years (Marathe & Talwar, 2015), although Baffes himself had already planned in 1955 to modify the surgical technique he had devised, so that the superior vena cava would now be exchanged with the left pulmonary veins. It is worth noting that during the two-year period 1954–1955, another young researcher at the Chicago Children's Hospital, Harold Albert, encouraged by Potts, devised a method for correcting TGA by implanting a prosthetic transseptal cardiac shunt: this unidirectional 'window' would be achieved by creating bilobed flaps of the interatrial septum, with each lobe covering the orifices of the vena cava. Albert published his canine experiments in 1955 but was unable to replicate them clinically (Albert, 1955). His idea nevertheless led to the concept of interatrial switching, which was subsequently developed by William Thortontont Mustard and colleagues in Toronto in 1963 (Albert, 1955; Konstantinov et al., 2004).

Extracorporeal Circulation and Open-Heart Surgery

These were years of major scientific and

technical discoveries and applications, particularly in the United States; there, in fact, great strides were being made towards the development of a device that would take over the heart's normal function during these open-heart surgical procedures. The pioneering work of DeBakey and Schmidt in 1934 had led to the creation of a machine consisting of a double pump capable of oxygenating the bloodstream (Holman et al., 2022); subsequent improvements made by Henry Dale (Nobel Laureate in Medicine in 1936), Edgar Schuster, John Heysham Gibbon and Walton Lillehei, with the assistance of researcher Richard DeWall, led to Lillehei's first use of the device in the operating theatre on 13 May 1955 during open-heart surgery (Holman et al., 2022). Naturally, Potts and his team also took an interest in the subject (Potts et al., 1952); the first attempts at extracorporeal circulation on living tissue, carried out at the research center led by our protagonist, had already begun in 1951, using a Dale-Schuster pump on a number of dogs, but given the technical difficulties and unsatisfactory results, the studies had to wait until the arrival of the heart-lung machine developed by DeWall, with which over 200 experiments on animal models and six clinical trials were carried out (Riker et al., 1962). In 1958, Potts and his team focused their efforts on a disc-type oxygenator coupled with a T3 Sigmamotor pump: survival rates in animal models were 100 per cent, so they proceeded to introduce it into clinical use. Over 400 patients underwent surgery using this extracorporeal circulation system over the following four years, primarily for ventricular septal defects, which were often associated with other congenital defects such as transposition of the great arteries, tetralogy of Fallot, pulmonary stenosis, ostium primum, aortic stenosis and atrioventricular canal defects (Riker et al., 1962). Potts and his team had developed their own model of a heart-lung machine, suitable for clinical use and fully functional, but the bubble oxygenator developed by DeWall was simpler and remained in use until the late 1970s (Riker et al., 1962).

Legacy of Willis John Potts

In October 1962, Potts was awarded the Ladd Medal, which recognizes pediatric surgeons

who have made a significant contribution to infant surgery and the care of newborns and children (Baffes, 1987; Riker, 1968). In 1965, he retired from the profession; having retired, he settled in Sarasota (Florida), a town with a vibrant cultural life (Baffes, 1987). On 5 May 1968, Willis Potts died of a heart attack; he was survived by his wife Henrietta (whom he married in 1922), two sons, a daughter and 14 grandchildren (Baffes, 1987; Riker, 1968). Willis John Potts was described by his colleagues as a perfectionist who demanded the very best from others and from himself; yet he could also be impatient when he failed to achieve the desired result. He was an innovator, delighted to be able to apply the findings of his own and others' research in the operating theatre, and an unrivalled teacher, capable of explaining and expressing himself directly and clearly (Baffes, 1987). His most remarkable trait, however, was the empathy he established with his young patients, a genuine feeling that had a positive impact on both their physical and psychological wellbeing: many of his colleagues recall meetings and ward rounds being interrupted by Potts so that he could play with his young patients (Baffes, 1987; Riker, 1968). According to his pupils and students, he was an excellent teacher and mentor, always ready to pass on his knowledge to others; but he could also be very direct and blunt when the situation or the mistake before his eyes was glaringly obvious. His skill and expertise have been passed down to us through his surgical instruments, many of which are still in use today, but also through his pupils: numerous surgeons whom he trained at the Chicago Children's Hospital have continued his work, refining surgical techniques and approaches. DeBoer became a pediatric cardiovascular surgeon and professor at Northwestern University Medical School; Farouk Idriss became head of the Cardiovascular Division at Children's Memorial Hospital in Chicago, as well as a professor at Northwestern University Medical School. John Raffensberger became director of the surgical department at Chicago Children's Hospital and author of a renowned textbook on pediatric surgery. Thomas Baffes, meanwhile, became head of the surgical department at Mount Sinai Hospital Medical Centre in Chicago (Baffes, 1987).

Potts' work contributed significantly to the advancement of surgery in the second half of

the 20th century and can be summarized in three keyways:

- the development of excellence in surgical techniques. Potts demanded the very best from himself and those around him: none of his trainee surgeons were permitted to look after his pediatric patients or enter the operating theatre until they had first demonstrated their technical and practical skills in the animal laboratory. Arterial anastomoses were still in their infancy at the time: Potts improved the technique for performing them through his own instruments and skill; his students learnt a great deal from this;
- the creation of specialized surgical instruments. The instruments designed by Potts and manufactured by Bruno Richter made surgical practice safer: these were not mere adaptations but designs specifically tailored to the surgical context. This made them highly valued, so much so that they are still featured in the catalogues of numerous manufacturers today; above all, they formed the foundation upon which many other giants of surgery were able to achieve their feats;
- innovative vision. Having read the work carried out by his colleagues, Potts decided to follow in their footsteps whilst refining their surgical technique; whilst always remaining aware of his own limitations, he constantly sought to bring the best available evidence and the results of his own and others' research into the operating theatre. Potts was also a remarkable planner and coordinator: in just over a year after his arrival, starting almost from scratch, he managed to create a model of training and organization that remained unique for years. This vision was further enhanced by his forthright nature and remarkable intellectual integrity: evidence of this is that in 1955 Potts wrote an editorial in JAMA criticizing pediatric surgical care in the United States, pointing out that across the whole country only eight hospitals had pediatric surgery program run by staff trained for that purpose (Potts, 1955).

It seems incredible that, despite Potts's enormous contribution, medical historiography

has treated him rather unfairly: much of the information gathered for this account has been drawn from the bibliographies of two key articles (the most recent of which dates from 1987), whilst other documents have proved difficult to access. We therefore hope to have paid tribute to this giant of the surgical world, whose ideas and instruments accompany us every day in our daily work.

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