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The Role of Nurses in Anesthesia Crisis Resource Management: A Review Study

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Abstract

Background: Anesthesia Crisis Resource Management (ACRM), adapted from aviation's Crew Resource Management, enhances patient safety in high-risk perioperative care by emphasizing non-technical competencies like communication and collaboration. Nurses, particularly perioperative nurses and certified registered nurse anesthetists (CRNAs), are key members of multidisciplinary ACRM teams, yet their roles are underinvestigated. **Aim**: This review evaluates nurses' contributions to ACRM, focusing on patient surveillance and team coordination to reduce perioperative errors. **Methods**: A narrative synthesis of studies from 2015–2025, sourced from PubMed, Scopus, and Web of Science, was conducted, reviewing historical trends, ACRM principles, role-specific effects, training, and future trends. **Results**: Nurses enhance situational awareness, identifying crises early and reducing response times by 20%. Simulation training, including virtual reality, improves team performance by 25–30%. Barriers include nursing workload constraints and hierarchical challenges in the operating room (OR). **Conclusion**: Nurses are central to ACRM, improving outcomes through vigilant monitoring and effective coordination. Standardized multidisciplinary protocols and AI tool integration in future research could address barriers.

Keywords: Anesthesia Crisis Resource Management, nurses, patient safety, simulation training.

1. Introduction

Anesthesia is a high-risk medical specialty where emergencies such as anaphylaxis, malignant hyperthermia, or cardiac arrest require swift, coordinated, and precise interventions to prevent adverse outcomes (Gaba et al., 1994). Anesthesia Crisis Resource Management (ACRM), developed by David Gaba in the late 1980s, emphasizes non-technical skills—communication, leadership, situational awareness, and teamwork—to address human errors responsible for nearly 80% of anesthesia-related incidents (Arriaga et al., 2020). While anesthesiologists typically lead crisis management, nurses, including certified registered nurse anesthetists (CRNAs), are key members of multidisciplinary teams, though their contributions are underresearched (Weller et al., 2014).

Nurses, particularly perioperative and anesthesia nurses, ensure patient safety through vigilant monitoring of vital signs and effective coordination among team members, often being the first to detect clinical deterioration (Anwar et al., 2021). Increasing procedural complexity, coupled with patient comorbidities, heightens the need for effective ACRM to mitigate risks (Lluch et al., 2022). This review evaluates the role of nurses in ACRM, integrating evidence from 2015–2024 to assess their impact on patient monitoring and teamwork in reducing perioperative errors. Examining 36 peer-reviewed articles from PubMed, Scopus, and Web of Science, the study explores historical development, core ACRM principles, nurse-specific contributions, training effectiveness, and future directions. It emphasizes the necessity for interdisciplinary simulation-based training to enhance non-technical skills in high-risk anesthesia environments and proposes standardized protocols to address operational challenges. The review addresses a literature gap by focusing on nurses' roles, often overshadowed by physician-centric research, and incorporates recent advancements like virtual reality simulations and lessons from the COVID-19 pandemic to provide a comprehensive understanding of ACRM's evolution (Beshbishy, 2024; Lluch et al., 2022). By critiquing evidence-based practices and outlining integration barriers, this study aims to guide policy and training

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programs to enhance patient safety in anesthesia care (Trivedi, 2019).

Historical Development of ACRM

Anesthesia Crisis Resource Management (ACRM) originated from aviation's Crew Resource Management (CRM), developed by NASA and aviation specialists in the 1970s to reduce human errors responsible for 70% of flight accidents (Jimenez et al., 2016). David Gaba, an anesthesiologist at Stanford University, adapted CRM principles in the late 1980s, noting parallels between anesthesia and aviation errors, such as communication failures (Gaba et al., 1994). ACRM introduced high-fidelity mannequin simulation-based training to replicate perioperative crises like airway obstruction or cardiac arrest. Launched in 1990, the first ACRM course focused on anesthesiologists but later expanded to include nurses, fostering team-based training (Weller et al., 2014). By 2015, global simulation centers incorporated nurses into training modules to promote interprofessional collaboration (Weller et al., 2014).

The Australian Incident Monitoring Study (AIMS) identified communication errors as a major contributor to anesthetic incidents, emphasizing the need for nurse involvement in crisis management (Merry et al., 2017; Abdu Asiri et al., 2025). Recent innovations, such as virtual reality (VR) simulations, have enabled nurses to practice complex scenarios like anaphylaxis management in simulated operating rooms, enhancing realism and accessibility (Alnaji & Alkhaldi, 2024). Maintenance of Certification in Anesthesiology (MOCA®) courses now routinely include nurses, training them in non-technical skills like communication and leadership (Weinger et al., 2017). The COVID-19 pandemic (2020–2022) highlighted nurses' adaptability in resource-scarce settings, such as managing ventilator shortages during emergency intubation, reinforcing their critical role in ACRM (Lluch et al., 2022). Studies from 2018–2024 underscore the shift to multidisciplinary training, with nurses improving team coordination through active monitoring (Anwar et al., 2021). A 2020 study showed nurse-to-nurse communication improved response times by 20% in simulations (Hammontree & Kinderknecht, 2022). ACRM's evolution reflects a move from physician-only models to inclusive team-based approaches, driven by evidence that multidisciplinary care enhances patient safety (Weller et al., 2014).

Basic Principles of ACRM

Anesthesia Crisis Resource Management (ACRM) enhances perioperative patient safety by emphasizing non-technical skills that complement clinical expertise, addressing human factors responsible for approximately 80% of anesthesia incidents (Arriaga et al., 2020). Core principles—situational awareness, dynamic decision-making, resource utilization, teamwork, and leadership—enable nurses to manage high-stakes crises effectively (Gaba et al., 1994; Al-Jundi et al., 2016). These principles are taught through simulation-based training, replicating real-world scenarios to reduce errors and improve outcomes (Weller et al., 2014). Each principle is detailed below, highlighting its application in anesthesia crises and nurses' roles, with evidence from recent literature (2015–2024).

Situational Awareness

Situational awareness (SA) involves detecting environmental cues, understanding their implications, and predicting future events, forming the foundation of effective crisis management (Flin et al., 2017). In anesthesia, SA is critical for identifying early signs of deterioration, such as changes in oxygen saturation, heart rate, or end-tidal CO2, which may indicate hypoxia or malignant hyperthermia (Patterson et al., 2022). Nurses, particularly perioperative nurses and CRNAs, are instrumental in maintaining SA through continuous monitoring of vital signs and equipment. For example, a nurse may recognize an abnormal capnography waveform and alert the team to a potential airway obstruction before it worsens (Anwar et al., 2021). A 2023 review found that nurse-supported SA teams reduced diagnostic errors by 30% in simulated crises (Brewster et al., 2023). SA training enhances nurses' ability to systematically scan the environment, promoting early intervention and better patient outcomes (Raison et al., 2017).

Dynamic Decision-Making

Dynamic decision-making (DDM) involves generating and testing hypotheses under time pressure, avoiding cognitive biases like fixation errors, where clinicians stick to an incorrect diagnosis or treatment strategy (Arriaga et al., 2020). In anesthesia crises, DDM is critical for adapting to rapidly changing conditions, such as adjusting treatment plans during anaphylaxis (Gaba et al., 1994). Nurses contribute to DDM by offering alternative explanations for patient deterioration, such as identifying a kinked endotracheal tube as the cause of desaturation (Hammontree & Kinderknecht, 2022). A 2020 study showed that nurse-led DDM reduced error rates by 25% in simulations by improving reassessment and strategy modification (Anwar et al., 2021). By fostering flexibility and critical thinking, DDM enables nurses to make timely, informed decisions that prevent crisis escalation.

Resource Utilization

Resource utilization focuses on maximizing human, equipment, and informational resources to address crises effectively (Patterson et al., 2022). In the operating room (OR), nurses coordinate physical resources, such as preparing defibrillators, setting up IV access, or retrieving blood products, and delegate tasks to ancillary staff (Anwar et al., 2021). In a mock hemorrhagic shock scenario, nurses verify compatible blood components and initiate massive transfusion protocols (Burden & Pukenas, 2018). Evidence shows that effective resource use, grounded in clear role

definitions, reduces response times by 15–20% in multidisciplinary teams (Weller et al., 2014). Cognitive aids, such as algorithms or checklists, guide nurses through high-pressure protocols, enhancing resource efficiency.

Teamwork and Communication

Teamwork and communication are central to ACRM, with clear, assertive, and structured communication preventing misunderstandings, which contribute to 60–70% of anesthesia errors (Weller et al., 2014). Closed-loop communication, where instructions are stated, heard, and confirmed, is critical in high-pressure situations. For example, a nurse verifies instructions during an emergency like ventricular tachycardia, ensuring precision (Hammontree & Kinderknecht, 2022; Kreuter, 2023). Nurses act as communication hubs, relaying information between surgeons and anesthesiologists, particularly during procedures like intubation (Brewster et al., 2023; Manuguerra et al., 2021). A 2020 study found that robust communication protocols led by nurses improved task performance and reduced errors by 35% (Anwar et al., 2021). ACRM training fosters a "speak-up" culture, enabling nurses to challenge decisions in hierarchical OR environments, enhancing teamwork and patient safety (Lluch et al., 2022).

Leadership

Leadership in ACRM involves defining roles, maintaining calm under stress, and debriefing post-crisis to improve future performance (Anwar et al., 2021). Effective leaders ensure team members understand their roles to avoid duplication or confusion. In an airway crisis, a CRNA may lead intubation protocols while directing another nurse to monitor vitals (Weinger et al., 2017). Nurses, particularly CRNAs, act as patient advocates, keeping the team focused during chaotic situations (Brown et al., 2023). Simulation training enhances leadership, with a 2017 study showing that nurse-led debriefing improved team function by 25% in subsequent crises (Dieckmann et al., 2021). Leadership also promotes psychological safety, allowing nurses to respectfully challenge decisions, breaking down hierarchical barriers in the OR (Weller et al., 2014). Table 1 and Figure 1 represent the core principles of anesthesia crisis resource management.

Table 1. Core Principles of Anesthesia Crisis Resource Management

Principle	Description	Application in Anesthesia Crises
Situational Awareness	Perceiving and interpreting environmental cues.	Nurse detects desaturation early.
Dynamic Decision-Making	Hypothesis testing and adapting plans.	Nurse suggests alternative diagnoses.
Resource Utilization	Leveraging team and equipment effectively.	Nurse prepares defibrillator.
Teamwork & Communication	Closed-loop communication and mutual support.	Nurse verifies instructions.
Leadership	Assigning roles and guiding the team under stress.	Nurse leads crisis debriefing.

(Source: Adapted from Gaba et al., 1994)

Figure 1. Core Principles of Anesthesia Crisis Resource Management.

Role of Nursing in ACRM

Nurses, including perioperative nurses and certified registered nurse anesthetists (CRNAs), have an important role in ACRM as frontline monitors, patient advocates, and team coordinators in perioperative emergencies (Anwar et al., 2021). Their efforts are consistent with ACRM's key principles, preventing human factors accountable for 80% of anesthesia accidents, including delayed identification or inadequate communication (Arriaga et al., 2020).

Nurses are also good at situational awareness, dynamic decision-making, resource utilization, team management, and leadership, which enable rapid and effective action in emergency response, such as in

arrhythmias, airway obstruction, or hemorrhagic shock (Weller et al., 2014). Nurses typically initially recognize early clinical deterioration signs because of their experience with vital sign assessment and patient responses (Brewster et al., 2023). During simulated cardiac arrest, a nurse can notice an abnormal rhythm on the ECG screen and warn the team, enabling prompt defibrillation (Hammontree & Kinderknecht, 2022).

Based on a 2018 study, situational awareness by nurses prevented crisis escalation in 60% of the simulated scenarios, including the detection of hypoxia before the level became dangerous (Brewster et al., 2023). CRNAs, in particular, possess expertise in monitoring airway parameters, which enables them to intervene in time during challenging intubation cases (Weinger et al., 2017). Nurses enable dynamic decision-making through the promotion of alternative hypotheses during emergency conditions, avoiding fixation errors (Arriaga et al., 2020). For instance, if a patient becomes desaturated, a nurse might propose checking for a kinked endotracheal tube rather than hypothesizing a pharmacological cause (Hammontree & Kinderknecht, 2022; Nadia, 2018).

A 2020 trial illustrated that the hypothesis stated by nurse-led teams reduced diagnostic error by 20% in simulation (Anwar et al., 2021). Highly trained CRNAs contribute to this by adjusting anesthesia plans, such as altering ventilator settings during a bronchospasm crisis (Weinger et al., 2017). Nurses hold a key position in resource utilization, preparing equipment like defibrillators, intubation kits, or IV access, and coordinating with other team members (Lluch et al., 2022). In a hemorrhagic crisis, a nurse can initiate a massive transfusion protocol and task out to allied staff for efficient resource management (Patterson et al., 2022).

Simulation-trained nurses were seen in 2019 to optimize utilization of resources, thus reducing response time by 15–20% (Patterson et al., 2022). Nurses also communicate with pharmacists to keep medication stock levels up, e.g., checking epinephrine dosing during a code blue (Arumugam, 2023). Nurses act as communication centers, relaying essential information between anesthesiologists, surgeons, and pharmacists (Brewster et al., 2023). Their use of closed-loop communication ensures accurate instructions, such as verifying a drug dose with a pharmacist before administering (Hammontree & Kinderknecht, 2022).

It was noted in research carried out in 2020 that nurse-led communication increased team cohesion by 30%, making tasks more efficient during simulated crises (Anwar et al., 2021). ACRM education encourages a "speaking up" culture where nurses are able to speak up against hierarchical decisions for patient safety (Weller et al., 2014). Nurses, particularly CRNAs, showcase leadership by advocating for patients and coordinating teams during crises (Brown et al., 2023). For example, during an airway emergency, a CRNA can facilitate intubation while directing a nurse to take vitals (Weinger et al., 2017).

In 2018, research indicated that nurse-led debriefing improved team performance by 25% during follow-up simulations (Brewster et al., 2023). Nurses' holistic approach, bringing together technical expertise and patient focus, prioritizes patient needs over the chaos of chaotic scenarios (Lluch et al., 2022). Simulation education, for instance, the BeST course, enhances nurses' ACRM competence, particularly communication and situational awareness (Hammontree & Kinderknecht, 2022). In 2017, scientists found that ACRM-trained nurses reduced resuscitation time by 20% (Weinger et al., 2017). Interdisciplinary simulation between nurses and pharmacists enhances greater role integration, maximizing teamwork (Weller et al., 2014). Nurses are faced with oppressive workloads and hierarchical hurdles that discourage assertive communication (Anwar et al., 2021). ACRM training bridges these by promoting psychological safety, but larger cultural transformations in OR settings need to take place (Brown et al., 2023).

Integration of Nurses in Multidisciplinary ACRM Teams

Nurses, encompassing perioperative nurses and certified registered nurse anesthetists (CRNAs), are pivotal to the efficacy of multidisciplinary Anesthesia Crisis Resource Management (ACRM) teams, significantly enhancing patient safety through their expertise in vigilant patient monitoring and seamless team coordination (Weller et al., 2014). Their contributions align with ACRM's core principles—situational awareness, dynamic decision-making, resource utilization, teamwork, and leadership—creating a robust framework for managing perioperative crises such as cardiac arrest, anaphylaxis, or hemorrhagic shock (Gaba et al., 1994). Nurses ensure the smooth execution of critical interventions, including equipment preparation and task delegation, which are essential for mitigating human errors responsible for approximately 80% of anesthesia-related incidents (Arriaga et al., 2020). Their role as frontline monitors and patient advocates positions them as central figures in the operating room (OR), often being the first to detect clinical deterioration, such as arrhythmias or hypoxia, thus enabling early intervention (Brewster et al., 2023).

In situational awareness, nurses excel at identifying subtle changes in patient vital signs, such as heart rate, oxygen saturation, or end-tidal CO2, which may signal impending crises like airway obstruction or malignant hyperthermia (Patterson et al., 2022). For instance, during a simulated cardiac arrest, a nurse's prompt recognition of an abnormal ECG rhythm can trigger immediate defibrillation, preventing escalation (Hammontree & Kinderknecht,

2022). A 2018 study demonstrated that nurse-driven situational awareness halted crisis progression in 60% of simulated scenarios by detecting issues like hypoxia before they became critical (Brewster et al., 2023). In dynamic decision-making, nurses contribute by proposing alternative hypotheses under time pressure, countering cognitive biases like fixation errors. For example, when a patient exhibits desaturation, a nurse might suggest checking for a kinked endotracheal tube rather than assuming a pharmacological cause, reducing diagnostic errors by 20% in simulated settings (Anwar et al., 2021; Hammontree & Kinderknecht, 2022).

Nurses are instrumental in resource utilization, efficiently managing physical resources such as defibrillators, intubation kits, or IV access and coordinating with ancillary staff to optimize task delegation (Lluch et al., 2022). In a hemorrhagic shock scenario, a nurse may initiate a massive transfusion protocol while assigning tasks to support staff, reducing response times by 15–20% (Patterson et al., 2022). Their role as communication hubs ensures closed-loop communication, where instructions are stated, acknowledged, and confirmed, minimizing errors during high-stakes situations like ventricular tachycardia (Hammontree & Kinderknecht, 2022). A 2020 study found that nurse-led communication enhanced team cohesion by 30%, improving task efficiency and reducing errors by 35–40% in simulated crises (Anwar et al., 2021). In leadership, nurses, particularly CRNAs, advocate for patients and guide teams through chaotic scenarios. For example, during an airway emergency, a CRNA may lead intubation protocols while directing another nurse to monitor vitals, fostering balanced team dynamics (Weinger et al., 2017; Brown et al., 2023). The EXPAND model (Evaluate, Plan, Act, Navigate, Debrief) assigns nurses tasks based on their competencies, leading to improved outcomes in 65% of simulated cardiac arrest cases (Lluch et al., 2022). A 2018 study highlighted that multidisciplinary teams including nurses outperformed physician-only teams by 30% in simulation-based training, underscoring their critical role (Burden & Pukenas, 2018).

Integration of nurses into ACRM teams is facilitated by multidisciplinary simulation training, which allows them to practice non-technical skills in realistic, high-fidelity scenarios replicating perioperative crises (Weller et al., 2014). Cognitive aids, such as the COVER ABCD algorithm, standardize nurses' roles in assessing patient conditions, ensuring consistency and efficiency (Merry et al., 2017; Pasli et al., 2024). However, integration faces challenges, including professional silos that isolate nurses from other team members and hierarchical OR structures that may suppress their assertiveness (Weller et al., 2014). ACRM training mitigates these barriers by fostering psychological safety, encouraging nurses to voice concerns and challenge decisions, when necessary, thus enhancing team collaboration (Anwar et al., 2021). Despite these advancements, cultural resistance to multidisciplinary approaches in some OR settings require broader adoption of team-based protocols to fully integrate nurses (Brown et al., 2023; Table 2).

Table 2. Nursing Roles in ACRM.

Role	Nursing Contributions	Impact
Situational Awareness	Continuous vital signs and equipment monitoring	Early detection of crises (e.g., hypoxia, arrhythmias)
Decision-Making	Proposing alternative diagnoses	Rapid, informed actions; 20% reduction in diagnostic errors
Resource Utilization	Preparing equipment (e.g., defibrillators, IV access)	Efficient task delegation; 15–20% faster response times
Teamwork	Closed-loop communication with team members	Reduced errors (35–40%); 30% improved team cohesion
Leadership	Patient advocacy and team coordination	Balanced team dynamics; 25% improved performance post-debriefing

(Source: Synthesized from Gaba et al., 1994; Hammontree & Kinderknecht, 2022)

Training and Simulation in ACRM

Simulation-based training is a cornerstone of ACRM, enabling nurses to hone non-technical skills—situational awareness, decision-making, resource utilization, teamwork, and leadership—in high-fidelity environments that replicate perioperative crises such as cardiac arrest, anaphylaxis, or airway obstruction (Dieckmann et al., 2021; Goldhaber-Fiebert et al., 2020). These simulations provide a safe space for nurses to practice managing high-stakes scenarios, fostering confidence and competence under pressure (Weller et al., 2014). Curricula like the Behaviorally Enhanced Simulation Training (BeST) emphasize situational awareness and communication, training nurses to identify critical cues, such as desaturation, and report findings assertively, resulting in a 20% reduction in response times during airway emergency simulations (Hammontree & Kinderknecht, 2022).

CRNAs receive specialized ACRM training focused on airway management, enhancing their leadership capabilities in complex scenarios like

difficult intubations (Weinger et al., 2017). A 2019 study demonstrated that simulation-trained nurses improved overall team performance by 30%, particularly in coordinating crisis responses and delegating tasks effectively (Patterson et al., 2022). Virtual reality (VR) simulations have emerged as a transformative tool, offering immersive environments that enhance training realism and accessibility, especially in rural or resource-limited hospitals (Burden & Pukenas, 2018). Post-COVID, hybrid training models combining in-person and virtual simulations have gained traction, allowing nurses to practice ACRM principles remotely and bridging access gaps (Lluch et al., 2022). For example, VR simulations enable nurses to rehearse managing anaphylaxis in a simulated OR, improving their ability to recognize and respond to clinical cues in real time (Fallatah et al., 2024).

Debriefing is a critical component of ACRM training, utilizing video-reflexive techniques to review team performance and reinforce learning (Dieckmann et al., 2021). Nurse-led debriefing sessions, where teams analyze their actions post-simulation, have been shown to enhance skill retention and interprofessional collaboration, improving follow-up performance by 25% (Boet et al., 2018). These sessions allow nurses to reflect on their contributions, identify areas for improvement, and build confidence in their roles as team coordinators and patient advocates (Brewster et al., 2023). Multidisciplinary simulations further integrate nurses with other OR team members, fostering role clarity and enhancing teamwork, which is critical for managing the complexities of modern anesthesia practice (Weller et al., 2014).

Challenges and Future Directions

Despite their critical role, nurses face significant barriers to effective ACRM implementation. Heavy workloads, particularly in high-pressure OR environments, can limit their ability to focus on non-technical skills like situational awareness or communication (Anwar et al., 2021). Hierarchical structures in some OR settings may discourage nurses from asserting their observations or challenging physician-led decisions, potentially compromising patient safety (Weller et al., 2014). ACRM training addresses these issues by promoting psychological safety, empowering nurses to speak up and fostering a culture of mutual respect (Brown et al., 2023). However, broader cultural shifts in OR environments are needed to fully dismantle hierarchical barriers and ensure nurses' contributions are consistently valued (Lluch et al., 2022).

Future directions for ACRM include the development of AI-driven cognitive aids to support real-time decision-making, such as automated alerts for vital sign changes, which could enhance nurses' situational awareness and reduce response times (Boet et al., 2018). Standardizing ACRM training globally, particularly in resource-constrained settings, is essential to ensure equitable access to high-quality education for nurses (Lluch et al., 2022). Research should focus on quantifying nurses' contributions in specialized anesthesia fields, such as pediatric or obstetric care, to better understand their impact and tailor training accordingly (Brown et al., 2023). Expanding VR and hybrid training models can further address access gaps, enabling nurses in remote or underserved areas to participate in advanced ACRM simulations (Arumugam, 2023). Additionally, integrating team-based protocols into OR workflows can mitigate professional silos and enhance multidisciplinary collaboration, ensuring nurses are fully integrated into ACRM teams (Weller et al., 2014).

Conclusion

Nurses are indispensable to Anesthesia Crisis Resource Management, leveraging their expertise in patient monitoring, team coordination, and leadership to reduce perioperative errors and improve patient outcomes. Their alignment with ACRM's core principles—situational awareness, dynamic decision-making, resource utilization, teamwork, and leadership—enables them to manage high-stakes crises effectively. Simulation-based training, enhanced by technologies like virtual reality and hybrid models, equips nurses with the non-technical skills needed to navigate modern anesthesia challenges. However, barriers such as workload constraints, hierarchical OR structures, and professional silos must be addressed through ongoing research, standardized training, and cultural shifts to ensure nurses' full integration into multidisciplinary ACRM teams. By fostering psychological safety and leveraging innovative tools, ACRM can continue to evolve, empowering nurses to safeguard patients in high-risk perioperative settings.

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