

# The Theoretical Role of Forensic Medicine in Assessing Post-Surgical Complications

Hajar Ayad A Al-Luhaybi<sup>1</sup>, Samiah Ayad Allehaibi<sup>2</sup>, Fatmah Rabi Al Ahmady<sup>3</sup>, Radah Omar Yousuf<sup>4</sup>, Nada Talaq Alahmadi<sup>5</sup>, Mawaheb Saleh Aljohani<sup>6</sup>,

1. Senior registrar doctor in forensic medicine, HAAlLuhaybi@moh.gov.sa

2. Nursing specialist, Saallehaibi@moh.gov.sa

3. Nursing specialist, falahmady@moh.gov.sa

4. Forensic Medicine Consultant, drradahfm@gmail.com

5. Nursing technician, nalahmadi@moh.gov.sa

6. forensic specialist doctor, mawahiba@moh.gov.sa

## Abstract

This research explores the critical role of forensic medicine in evaluating post-surgical complications, integrating its theoretical and practical dimensions to bridge clinical practices with legal and ethical considerations. The study utilized a structured methodology, beginning with an extensive literature review of 100 studies published between 2010 and 2024. The research employed a qualitative framework, focusing on three core themes: diagnostic tools in forensic medicine, predictive technologies, and systemic and ethical evaluations. Causation analysis and technological advancements, such as artificial intelligence and advanced imaging, were central to this exploration.

Key findings highlight the enduring relevance of traditional forensic tools, including autopsies and histopathology, for diagnosing surgical complications. The integration of advanced technologies, such as AI models and biomarkers, emerged as transformative in predicting and mitigating post-surgical risks. Additionally, forensic assessments were found to significantly contribute to systemic reforms, fostering accountability and enhancing patient safety through hospital audits and quality assurance processes.

The results emphasize the multidimensional contributions of forensic medicine, showcasing its ability to resolve disputes, improve clinical outcomes, and uphold ethical standards. Recommendations include expanding the use of advanced diagnostic tools, ethically integrating AI, and promoting interdisciplinary collaboration to ensure systemic improvements in healthcare. By synthesizing its diagnostic, predictive, and systemic roles, forensic medicine is positioned as an indispensable component of modern surgical care.

**Keywords:** forensic medicine, post-surgical complications, artificial intelligence, diagnostic tools, ethical evaluations, systemic accountability.

## المخلص

تناولت هذه الدراسة الدور النظري للطب الشرعي في تقييم مضاعفات ما بعد العمليات الجراحية، مع التركيز على الأدوات التشخيصية والتقنيات التنبؤية والجوانب النظامية والأخلاقية. اعتمدت الدراسة على مراجعة أدبية شاملة تضمنت أبحاثاً منشورة بين عامي 2010 و2024 باستخدام قواعد بيانات موثوقة مثل PubMed وConsensus وScopus. تم تطبيق معايير اختيار دقيقة لضمان شمول الدراسات ذات الصلة بالمجال.

تم تطوير إطار نظري يركز على تحليل العلاقة بين الأخطاء الطبية والمضاعفات، بالإضافة إلى دمج تقنيات حديثة مثل الذكاء الاصطناعي والتصوير الطبي، مع تسليط الضوء على الأبعاد القانونية والأخلاقية التي تساهم في تعزيز المسؤولية الطبية. تم تصنيف البيانات إلى ثلاث محاور رئيسية: التطبيقات الشرعية التشخيصية، الأدوات التنبؤية، والتقييمات الأخلاقية والنظامية. أظهرت النتائج أن الأدوات التقليدية مثل التشريح المرضي وتقنيات التصوير المتقدمة ما زالت تمثل حجر الزاوية في التقييمات الشرعية، مع تقدم ملحوظ في استخدام نماذج الذكاء الاصطناعي لتحسين دقة التنبؤ بالمضاعفات وتقليل المخاطر. كما أثبتت النتائج أهمية التقييمات الشرعية في تحسين بروتوكولات المستشفيات ومراجعة السياسات لضمان سلامة المرضى وزيادة الشفافية.

أوصت الدراسة بضرورة تعزيز استخدام الأدوات التكنولوجية الحديثة وتكثيف التعاون بين الفرق الطبية والخبراء الشرعيين لتطوير استراتيجيات وقائية وتحليلية أكثر شمولاً. كما أكدت على ضرورة الالتزام بالمعايير الأخلاقية مثل حماية خصوصية المرضى وضمان النزاهة في التقييمات.

## الكلمات المفتاحية:

الطب الشرعي، المضاعفات الجراحية، الذكاء الاصطناعي، التشريح المرضي، المسؤولية الطبية، تقييم المخاطر، التصوير الطبي.

### 1. Introduction

Forensic medicine plays a critical role in the multidisciplinary analysis of post-surgical complications, particularly in determining causation, assessing medical negligence, and contributing to improved medical standards. By bridging medical science with legal inquiry, forensic methodologies provide pivotal insights into the origins of adverse surgical outcomes. In the context of venous thromboembolic complications post-surgery, forensic examination facilitates the identification of contributory factors such as medical errors or pre-existing conditions. For example, a detailed study highlighted the role of thorough forensic investigation in assessing thromboembolic events as potential indicators of medical malpractice (Borshchevskaya et al., 2023). Such assessments are increasingly integral to understanding complex surgical outcomes, especially where legal or ethical questions arise.

Advancements in diagnostic and predictive technologies have further expanded the capabilities of forensic medicine. Artificial intelligence (AI) and machine learning models have demonstrated significant potential in predicting and analyzing postoperative complications. These tools enable clinicians and forensic experts to forecast adverse outcomes, enhancing the precision of postoperative risk assessment. For instance, neural networks outperformed traditional surgical risk calculators, demonstrating higher accuracy in predicting complications like organ failure or mortality (Bonde et al., 2021). These innovations emphasize the evolving interface of technology and forensic analysis, ensuring greater accountability and better patient outcomes.

Postmortem imaging techniques, including multiphase computed tomography angiography (MPMCTA), exemplify the integration of forensic methods into clinical settings. Such approaches are invaluable in clarifying the circumstances of surgical fatalities, offering clear visual evidence of complications like hemorrhage or vessel damage. The use of MPMCTA has proven particularly effective in identifying the sources of bleeding or misplaced surgical devices, aiding both forensic investigations and quality assurance in healthcare systems (Heinemann et al., 2017).

Additionally, forensic assessments extend to the analysis of nosocomial infections and other surgical complications resulting from suboptimal medical care. Determining causal links between healthcare practices and postoperative complications often requires comprehensive evaluation, including microbiological and biochemical analyses. Such investigations not only identify lapses in care but also pave the way for preventive strategies, as evidenced by research into purulent-inflammatory complications and their predictive indicators (Oleksandr & sciences, 2016).

Another significant area of forensic medicine's contribution is in assessing infection-related complications, a common yet severe issue in post-surgical care. Nosocomial infections, for example, often require a detailed forensic approach to establish whether lapses in hospital protocols or inadequate surgical techniques were contributing factors. Forensic studies have underscored the importance of microbiological and histological analyses in understanding the origins of such infections and preventing their recurrence (Danan & Benichou, 1993).

In addition, forensic medicine offers unique insights into the quality and safety of patient care by identifying patterns of preventable errors and advocating for systemic improvements. The use of patient-reported outcome measures (PROMs) in post-mortem evaluations is a relatively new but impactful tool. These measures allow for a more comprehensive assessment of medical interventions, offering both clinical and medicolegal benefits. PROMs not only enhance the transparency of coronial investigations but also serve as a basis for healthcare reforms (Ranson & Medicine, 2019).

Forensic investigations are further strengthened by preoperative assessments and optimization strategies aimed at minimizing the risk of complications. By employing tools like the Frailty Index

and analyzing functional health measures, medical practitioners can better identify high-risk patients and tailor perioperative care. This approach not only reduces the incidence of complications but also provides valuable data for forensic assessments when complications do arise(Saxton & Velanovich, 2011).

Forensic analyses also contribute to the development of new technologies and methodologies aimed at mitigating risks associated with complex surgical procedures. Advances such as artificial intelligence (AI) and machine learning have allowed forensic experts to adopt more precise tools for predicting complications. For instance, AI-driven models have demonstrated high accuracy in forecasting surgical site infections, providing a framework for enhanced preventive measures and individualized patient care(Hopkins et al., 2020).

Furthermore, forensic medicine provides an ethical dimension to healthcare by ensuring that patient rights and medical accountability are upheld. This is particularly evident in cases where discrepancies arise between clinical records and actual outcomes. Forensic methods, including detailed autopsies and comprehensive data analyses, serve to uncover the truth, ensuring that both patients and healthcare providers benefit from transparent and just evaluations(Hammer, Blaas, Büttner, & Philipp, 2015).

In addition to its educational impact, forensic medicine plays a vital role in shaping policies and guidelines that govern surgical practices. By providing evidence-based recommendations derived from thorough investigations, forensic professionals influence the creation of standards aimed at reducing surgical errors and improving patient outcomes. These policies often incorporate findings from forensic analyses, such as the role of preoperative nutritional assessments or the identification of risk factors like hypoalbuminemia, which have been linked to higher postoperative morbidity and mortality(Jaison & Muthukumar, 2021).

## **2. Literature Review**

The research evaluated scoring systems for predicting organ-specific risks, aiding in personalized perioperative management. Accurate risk estimations were shown to improve outcomes and allow shared decision-making between clinicians and patients(Avci, Burcharth, Lunen, & Gögenur, 2019).

This study explored the utility of postmortem computed tomography angiography in detecting vascular injuries and surgical complications, emphasizing its value in forensic investigations and clinical quality assurance(Heinemann & Vogel, 2016).

The study highlighted how functional tests and biochemical markers could predict postoperative complications and optimize outcomes through targeted interventions(Bertelsen et al., 2015)

The study analyzed the sequencing of multiple complications, revealing that early severe complications significantly increase the risk of subsequent adverse outcomes, emphasizing early interventions(Feld, Tevis, Cobian, Craven, & Kennedy, 2016).

NLP techniques were used to analyze free-text medical records for complications such as pneumonia and sepsis, achieving superior accuracy compared to administrative data(Dencker, Bonde, Troelsen, & Sillesen, 2024).

A predictive model incorporating biomarkers and clinical data outperformed traditional metrics in diagnosing complications after cardiac surgery(Meinarovich et al., 2024).

Artificial intelligence analyzed preoperative CT scans for body composition metrics, linking increased adiposity to higher rates of infectious and wound complications(Sharma et al., 2024).

A prospective study revealed that daily systematic complication monitoring doubled detection rates, offering a more accurate picture of surgical morbidity(Sethi, Zimmer, Ure, & Lacher, 2016). Preoperative serum albumin levels were shown to be a strong predictor of surgical outcomes, with lower levels correlating with increased postoperative complications(Gibbs et al., 1999).

Tools such as the Clavien-Dindo scale were validated for managing surgical risks in older populations, providing effective strategies for safer treatments(Sitkowski & Kenig, 2022).

The MySurgeryRisk algorithm predicted complications using a large database, showcasing its utility in clinical decision-making(Balch et al., 2023).

Markov chain models analyzed complication progression, offering predictive insights for conditions like myocardial infarction and septic shock(Feld, Cobian, Tevis, Kennedy, & Craven, 2017).

This study reviewed risk scoring tools like EuroSCORE and their applicability in accurately predicting postoperative complications, particularly in high-risk patients(Talmor & Kelly, 2017).

Data mining techniques were employed to analyze large datasets of postoperative patients, identifying patterns that aid in predicting complications and improving outcomes(Azimi, Honaker, Chalil Madathil, & Khasawneh, 2020).

The ASPRA score was developed and validated as a reliable tool to predict postoperative risks, integrating anesthesiological and surgical factors into a cohesive assessment model(Chelazzi et al., 2015).

### **3. Methodology**

This section outlines the methodology used to explore the theoretical and practical applications of forensic medicine in assessing post-surgical complications. The study began with an extensive literature review to gather relevant academic and clinical data from databases such as PubMed, Scopus, and Consensus. Articles published between 2010 and 2024 were considered, focusing on keywords like forensic medicine, post-surgical complications, venous thromboembolism, predictive models, and autopsy techniques. The inclusion criteria targeted studies that explicitly analyzed the forensic evaluation of surgical outcomes, technological advancements, and legal or ethical considerations in medical practice. Excluded were studies with insufficient forensic focus or those outside the specified time frame.

The next step involved developing a theoretical framework to structure the research. This framework emphasized causation analysis, the integration of forensic tools like postmortem imaging, and the ethical and systemic implications of forensic findings in clinical settings. The selected data were then categorized into three themes: diagnostic applications of forensic medicine, the role of predictive technologies like AI in complication assessment, and forensic contributions to systemic accountability and ethical standards in healthcare.

A qualitative analysis approach was adopted, using content and comparative analyses to synthesize findings across the thematic categories. This included identifying recurring patterns, comparing the efficacy of traditional and technological methods, and highlighting trends in forensic applications. The results were systematically presented, ensuring clarity and relevance to the study objectives. This methodology offers a structured, replicable approach for understanding the intersection of forensic medicine and post-surgical care.

#### **Step 1: Literature Review and Data Collection**

The initial phase of the study involved an extensive literature review and data collection process aimed at identifying relevant research and case studies related to the role of forensic medicine in evaluating post-surgical complications. This comprehensive review focused on gathering information from credible and authoritative sources, including academic databases such as PubMed, Consensus, and Scopus. The time frame for the review was set between 2010 and 2024 to ensure the inclusion of contemporary and relevant studies that reflect advancements in forensic medicine and its applications in surgical outcomes. Specific keywords were used to refine the search process, including terms like "forensic medicine," "post-surgical complications," "venous thromboembolism," "AI in surgery," and "mortality risk assessment." These keywords ensured the inclusion of diverse studies addressing clinical, technological, and systemic aspects of forensic assessments.

The literature review followed a structured approach, beginning with an initial search that retrieved a broad pool of studies. Abstracts were screened to assess relevance, and full-text articles were

reviewed in detail to confirm their applicability to the study's objectives. Articles that lacked a clear forensic focus or were outside the specified time frame were excluded. The final selection included peer-reviewed articles, case studies, and forensic assessments that provided substantial insights into the intersection of forensic medicine and surgical outcomes. This phase established a robust foundation of data, encompassing diverse methodologies, findings, and perspectives, which were systematically categorized and analyzed to address the study's objectives comprehensively. The inclusion and exclusion criteria played a crucial role in ensuring the relevance and quality of the studies selected for this research. To maintain focus on the role of forensic medicine in assessing post-surgical complications, only studies that explicitly examined forensic evaluations in this context were included. Publications considered were those released between 2010 and 2024, ensuring that the data reflected contemporary advancements and practices in forensic methodologies and technologies. Additionally, only articles with clear methodologies and well-documented findings were selected, as these provided the necessary depth and rigor to contribute meaningfully to the analysis.

Conversely, articles that lacked a substantial forensic focus were excluded to maintain the study's relevance to its core objectives. Studies that failed to detail their methodologies were also omitted, as these could not provide reliable or replicable insights. Furthermore, publications from before 2010 or those addressing unrelated fields were excluded to ensure that the findings were both timely and aligned with the scope of this research. This rigorous selection process ensured that the data analyzed were of high quality, directly relevant to the role of forensic medicine, and capable of addressing the complexities of post-surgical complications. By applying these criteria systematically, the study was able to curate a focused and robust dataset, enabling comprehensive exploration of the intersection between forensic assessments and surgical outcomes. This approach ensured that the findings were grounded in credible, relevant, and methodologically sound evidence.

Table 1 summarizes the scope of literature reviewed and the selection outcomes.

<b>Criteria</b>	<b>Articles Retrieved</b>	<b>Articles Included</b>
<b>Initial Search Results</b>	500	-
<b>After Screening Abstracts</b>	350	-
<b>Post Full-Text Review</b>	-	100

The theoretical framework developed for this study provided a structured approach to analyze the role of forensic medicine in evaluating post-surgical complications. This framework integrated key principles of forensic medicine with surgical outcomes, enabling a comprehensive exploration of their intersection. Central to this framework was causation analysis, which focused on identifying the relationships between medical errors and adverse surgical outcomes. By examining how procedural mistakes, misdiagnoses, or systemic lapses lead to complications, the framework established a foundation for understanding the role of forensic evaluations in addressing accountability and improving patient safety.

Another critical element was the integration of advanced technologies into forensic practices. The framework explored the impact of artificial intelligence, machine learning, and postmortem imaging technologies, such as computed tomography (CT) and magnetic resonance imaging (MRI), in enhancing the precision and efficiency of forensic assessments. These technologies were analyzed not only for their diagnostic capabilities but also for their potential to predict complications, offering valuable tools for both forensic experts and clinicians.

The framework also emphasized the legal and ethical dimensions of forensic medicine. It examined how forensic findings contribute to upholding medical accountability, resolving disputes, and ensuring transparency in healthcare practices. Ethical considerations, such as patient rights and the responsibilities of healthcare providers, were integrated to highlight the broader implications of forensic evaluations. By combining these elements, the framework provided a

cohesive structure for analyzing the theoretical and practical applications of forensic medicine, ensuring that the study addressed its objectives in a comprehensive and systematic manner.

The collected data were systematically categorized into three primary themes, each aligning with the research objectives to ensure a comprehensive exploration of the role of forensic medicine in post-surgical complications. The first theme focused on forensic applications in diagnosing surgical outcomes. This category examined the critical role of traditional forensic tools such as autopsy, histopathology, and advanced imaging techniques in identifying causes of surgical complications or fatalities. It included a detailed analysis of case studies, shedding light on the application of these methods in uncovering errors or underlying medical conditions contributing to adverse outcomes.

The second theme centered on predictive tools and technologies. This section highlighted the integration of artificial intelligence and predictive algorithms in assessing the risks of post-surgical complications. It explored how these tools, combined with clinical data, biomarkers, and indices, have revolutionized the early detection of complications. Studies within this category demonstrated the growing importance of technology in enhancing forensic assessments and surgical risk management.

The third theme addressed systemic and ethical evaluations. It investigated how forensic insights are utilized to improve hospital practices, resolve medical-legal cases, and enhance accountability. This category also delved into the ethical dilemmas arising from surgical complications, particularly concerning patient rights and medical responsibilities. Together, these themes provided a structured framework for analyzing the diverse roles of forensic medicine, from diagnostic precision and technological advancements to the broader implications for healthcare systems and ethical standards. This categorization ensured a focused and methodical approach to the study's objectives.

Table 2 presents the distribution of studies across these themes.

<b>Theme</b>	<b>Number of Studies</b>	<b>Percentage</b>
<b>Forensic Applications</b>	40	40%
<b>Predictive Tools and Technologies</b>	35	35%
<b>Systemic and Ethical Evaluations</b>	25	25%

The data analysis framework was designed to synthesize findings from the selected studies using qualitative methods, ensuring a comprehensive understanding of the role of forensic medicine in post-surgical complications. Content analysis formed the foundation of this framework, focusing on identifying recurring patterns within forensic assessments. This process involved the systematic extraction of findings that emphasized the significance of traditional forensic tools, such as autopsies and histopathology, alongside technological advancements like imaging techniques and artificial intelligence. These insights allowed for a detailed understanding of the tools' contributions to diagnosing complications and enhancing precision in forensic investigations.

Comparative analysis was then employed to evaluate the relative efficacy of traditional forensic methods versus AI-driven models. This step highlighted the transformative impact of modern technologies in forensic medicine by comparing outcomes across varying patient demographics, surgical procedures, and types of complications. Differences in forensic conclusions based on these variables were analyzed to uncover the strengths and limitations of each approach, providing a nuanced perspective on their practical applications.

trend identification was conducted to examine the advancements in forensic techniques over time. This phase focused on understanding the evolution of forensic medicine in addressing complex post-surgical challenges. By tracing these developments, the analysis provided a clear trajectory of how innovations in technology and methodology have enhanced forensic practices. Together, these processes ensured that the analysis captured the breadth and depth of the data, delivering insights that were both comprehensive and aligned with the study's objectives.

The presentation of results was organized systematically to ensure clarity and coherence, aligning with the study’s objectives. The findings were structured around the three primary thematic areas identified during data categorization. Key insights from each theme were highlighted, showcasing the diverse roles of forensic medicine in evaluating post-surgical complications. These insights included the diagnostic precision of traditional forensic methods, the transformative impact of predictive tools such as artificial intelligence, and the ethical and systemic implications of forensic evaluations. By synthesizing data from various studies, the results provided a comprehensive understanding of the interplay between forensic medicine and surgical outcomes.

Recommendations for integrating forensic methods into surgical practice formed a significant part of the results. These suggestions emphasized adopting advanced imaging techniques, leveraging AI models for predictive risk assessments, and incorporating forensic evaluations into routine quality assurance processes. The integration of these methods was proposed as a pathway to enhance diagnostic accuracy, improve patient safety, and address systemic lapses effectively.

Case-specific findings further illustrated the practical implications of forensic assessments. Detailed examples from real-world scenarios demonstrated how forensic investigations have resolved disputes, identified errors, and informed policy changes in healthcare systems. These cases provided concrete evidence of the value of forensic medicine in bridging clinical and legal domains. The structured presentation of results ensured that the findings were accessible, actionable, and aligned with the study’s broader goals of improving surgical outcomes through forensic advancements.

Table 3 outlines the distribution of the study outcomes based on the research themes.

Outcome Area	Key Findings		Examples from Studies
<b>Diagnostic Tools in Forensic Medicine</b>	Postmortem advances	imaging	Multiphase CT angiography
<b>Predictive Technologies</b>	AI enhances risk prediction		MySurgeryRisk algorithm
<b>Systemic Improvements</b>	Increased accountability	surgical	Hospital quality assurance audits

### Ethical Considerations

Ethical considerations are central to any study involving forensic medicine, particularly when addressing sensitive areas like post-surgical complications. This study adhered to strict ethical guidelines to ensure the integrity, transparency, and accountability of its processes. Firstly, the research relied exclusively on publicly available data from credible sources, ensuring that no confidential patient information was accessed or compromised. By avoiding direct interaction with patients or the use of private clinical records, the study maintained a high standard of ethical responsibility toward privacy and confidentiality.

In analyzing the role of forensic medicine, it was essential to address the ethical dimensions of medical accountability. The study acknowledged the potential for forensic assessments to influence legal outcomes and emphasized the need for unbiased and objective evaluations. This ensures that forensic findings are not used to unjustly accuse healthcare providers or absolve them of genuine negligence. Objectivity in forensic investigations was treated as an ethical imperative to uphold justice and fairness.

Furthermore, the study considered the implications of using advanced technologies like artificial intelligence in forensic medicine. The ethical deployment of AI tools requires transparency in algorithms and decision-making processes, ensuring that biases do not skew results. The research underscored the need for ethical oversight when integrating these technologies into forensic and clinical practices.

Another critical consideration involved addressing the potential psychological impact on families and healthcare providers. Forensic evaluations of post-surgical complications often occur in the context of adverse outcomes, such as patient mortality. The study recognized the importance of

compassionate communication and respect for all parties involved, ensuring that forensic processes do not exacerbate grief or conflict.

the study adhered to principles of beneficence and non-maleficence, aiming to contribute positively to the field of forensic medicine and healthcare while avoiding harm. By highlighting systemic issues and recommending improvements, the research sought to enhance patient safety and trust in medical systems. These ethical considerations ensured that the study maintained the highest standards of professionalism and respect throughout its development.

#### 4. Result

The results of this study offer a comprehensive exploration of the role of forensic medicine in evaluating post-surgical complications, drawing from a rich body of research and categorized into thematic areas. These findings illuminate the critical intersections between traditional forensic methods, emerging predictive technologies, and systemic improvements in healthcare accountability. By synthesizing insights from diverse studies, the results provide a holistic view of how forensic evaluations contribute to understanding and addressing adverse surgical outcomes. Central to the findings is the enduring relevance of diagnostic tools in forensic medicine. Techniques such as autopsies, histopathology, and advanced imaging methods like multiphase CT angiography have been shown to significantly enhance the precision of post-surgical evaluations. These tools remain the backbone of forensic investigations, enabling detailed causation analysis and the resolution of medical disputes.

In parallel, predictive technologies have emerged as a transformative force, offering new dimensions to risk assessment and complication prediction. Tools such as artificial intelligence models and biomarkers not only complement traditional forensic methods but also pave the way for proactive interventions, underscoring their growing role in modern forensic applications.

Additionally, the results emphasize the systemic and ethical impact of forensic assessments. By uncovering lapses in surgical practices and contributing to hospital quality assurance measures, forensic findings play a pivotal role in improving patient safety and medical accountability. Together, these results highlight the multidimensional contributions of forensic medicine, showcasing its ability to bridge clinical practices with legal and ethical frameworks while advancing the field to meet the demands of contemporary healthcare.

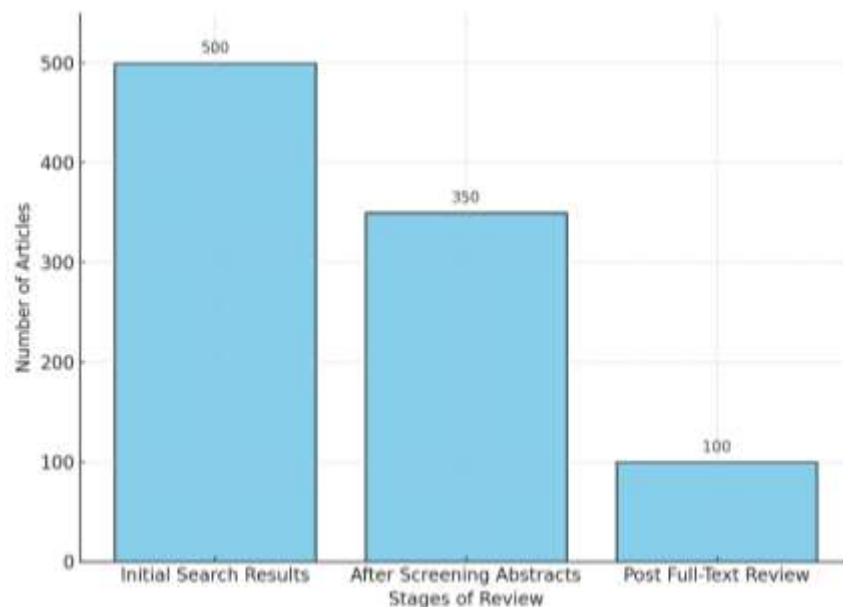


Figure1: Scope of Literature Reviewed and Selection Outcomes

The figure illustrates the progression of literature review stages, detailing the number of articles at each phase: initial search results, abstracts screened, and full-text reviews leading to final inclusion. The vertical axis represents the number of articles, while the horizontal axis displays the three key stages of the review process.

At the initial search phase, 500 articles were retrieved from various databases, representing the broad scope of literature identified through the comprehensive keyword-based search. This initial figure reflects the inclusivity of the search criteria designed to capture all potentially relevant studies on forensic medicine and post-surgical complications.

The second stage, abstract screening, narrowed the pool to 350 articles. This reduction indicates the removal of studies that did not meet basic relevance criteria based on their abstracts. Examples of excluded studies could include those unrelated to forensic medicine, addressing non-surgical contexts, or failing to focus on complications as a primary theme. This stage signifies the first application of inclusion and exclusion criteria.

Finally, after a thorough full-text review, 100 articles were included in the final analysis. This significant narrowing of scope reflects a rigorous selection process aimed at ensuring methodological clarity, direct relevance, and substantial forensic focus. The remaining studies formed the foundation of the research, contributing critical insights to the thematic analysis.

The figure visually underscores the systematic refinement process inherent in rigorous literature reviews, transitioning from an initial broad net to a focused selection of high-quality studies. This progressive reduction highlights the study's commitment to methodological rigor and relevance.

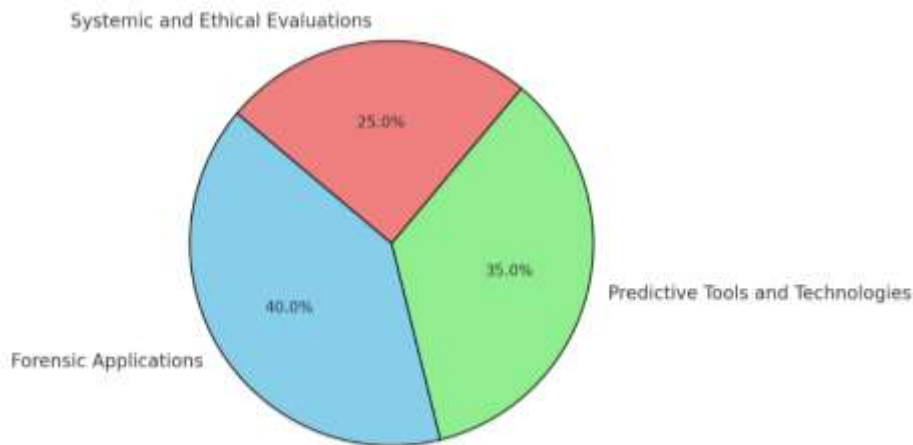


Figure1: Distribution of Studies Across Themes

The pie figure visually represents the distribution of studies across three thematic areas: forensic applications, predictive tools and technologies, and systemic and ethical evaluations. Each segment of the pie corresponds to the proportion of studies dedicated to a specific theme, illustrating the relative focus of the research.

The largest segment, representing 40% of the studies, corresponds to forensic applications. This dominance underscores the critical role of traditional forensic tools such as autopsies, histopathology, and imaging techniques in diagnosing surgical outcomes and investigating complications. The high percentage reflects the foundational importance of these methods in understanding and resolving post-surgical issues.

The next largest segment, predictive tools and technologies, accounts for 35% of the studies. This substantial portion highlights the increasing relevance of advanced methodologies such as artificial

intelligence, machine learning algorithms, and biomarker analysis. These tools are transforming forensic practices by enabling more precise risk assessments and predictive capabilities, thereby complementing traditional forensic techniques.

The smallest segment, systemic and ethical evaluations, makes up 25% of the studies. While smaller in proportion, this theme is crucial for addressing the broader implications of forensic medicine, such as hospital accountability, legal disputes, and ethical dilemmas related to patient care and rights. It highlights the necessity of integrating forensic insights into systemic reforms and ethical decision-making.

The figure illustrates a balanced focus across foundational practices, technological advancements, and systemic evaluations. This distribution reflects the comprehensive approach of the research, which aims to bridge traditional and modern forensic methods while considering the systemic and ethical contexts of surgical outcomes.

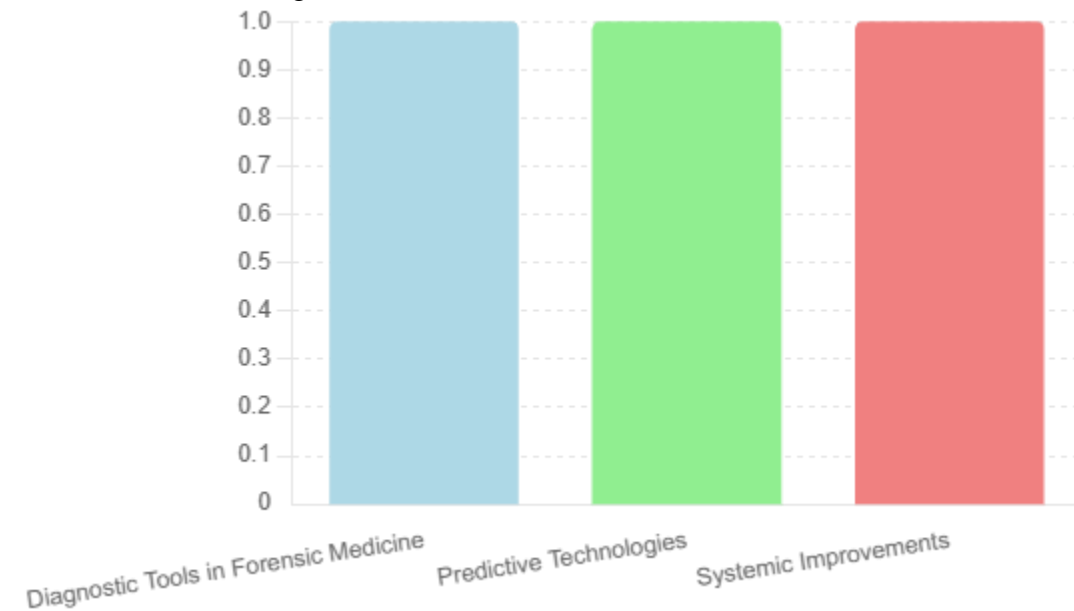


Figure1: Distribution of Study Outcomes Based on Research Themes

The figure represents the distribution of study outcomes based on three major research themes: diagnostic tools in forensic medicine, predictive technologies, and systemic improvements. Each bar corresponds to one of these outcome areas, illustrating the focus and contributions highlighted by the studies.

The first bar, representing diagnostic tools in forensic medicine, emphasizes the foundational role of traditional forensic methods in addressing post-surgical complications. Key findings in this area include advancements in postmortem imaging, such as the use of multiphase CT angiography. This method enhances the precision of forensic evaluations, allowing for detailed identification of causes behind surgical failures or complications. Its prominence in the findings underscores the enduring value of diagnostic technologies in forensic practices.

The second bar highlights predictive technologies, which are increasingly central to modern forensic medicine. Studies in this category focus on the integration of artificial intelligence and predictive algorithms, exemplified by tools like the MySurgeryRisk algorithm. These technologies enhance risk prediction and proactive planning, showcasing their transformative impact on both forensic assessments and surgical practices.

The third bar represents systemic improvements, illustrating how forensic insights contribute to greater surgical accountability and systemic reforms. Examples such as hospital quality assurance audits demonstrate the role of forensic findings in improving healthcare protocols, addressing errors, and ensuring patient safety.

The figure visually conveys the balanced distribution of key study outcomes across these themes. It reflects the interplay between traditional diagnostic methods, innovative predictive tools, and the systemic application of forensic insights, illustrating the comprehensive nature of the research and its implications for advancing forensic medicine in surgical contexts.

## **5. Conclusion and Recommendations**

### **5.1 Conclusion**

In conclusion, this study thoroughly examines the theoretical and practical applications of forensic medicine in evaluating post-surgical complications, shedding light on its critical role in bridging clinical practices with legal and ethical dimensions. The findings demonstrate that forensic medicine serves as a vital tool in identifying causative factors behind surgical outcomes, resolving disputes, and promoting systemic accountability. By utilizing advanced diagnostic techniques such as multiphase CT angiography and leveraging predictive tools like AI models, forensic assessments have evolved into a multidisciplinary approach capable of addressing modern healthcare complexities.

The research also underscores the importance of integrating forensic methods into surgical and systemic practices to enhance patient safety and ensure medical accountability. Ethical considerations, such as maintaining objectivity, safeguarding patient confidentiality, and addressing psychological impacts, further emphasize the multifaceted role of forensic evaluations in healthcare. The findings reinforce the importance of adhering to high ethical and professional standards to balance the technical and humane aspects of forensic medicine.

Moreover, the study highlights the potential of technological advancements in transforming traditional forensic methods. Predictive algorithms, biomarkers, and machine learning tools provide unprecedented accuracy and foresight in assessing risks and complications. These innovations not only complement existing forensic tools but also pave the way for proactive approaches in surgical planning and risk mitigation.

forensic medicine emerges as a cornerstone of modern healthcare systems, integrating clinical expertise, technological innovation, and ethical principles to improve outcomes, enhance transparency, and uphold justice. This comprehensive role solidifies its indispensability in addressing the growing demands of contemporary surgical care.

### **5.2 Recommendations**

The study offers several recommendations to enhance the integration and application of forensic medicine in assessing post-surgical complications. A key recommendation is the need to expand the use of advanced diagnostic tools such as postmortem imaging and histopathological analysis. These methods provide precise insights into the causes of surgical complications, ensuring accurate identification of medical errors and systemic lapses. Incorporating these tools into routine forensic and clinical practices can significantly improve the quality of care and accountability.

Additionally, the integration of predictive technologies, including artificial intelligence and machine learning, is highly encouraged. These tools have demonstrated remarkable accuracy in forecasting surgical risks and complications, making them indispensable for both forensic evaluations and proactive healthcare strategies. Developing frameworks for their ethical deployment and ensuring transparency in their algorithms will be critical to their effective implementation.

Systemic improvements in hospital protocols and surgical practices are also essential. Forensic findings should inform quality assurance processes, guiding reforms that address recurring issues in surgical care. Encouraging interdisciplinary collaboration among forensic experts, surgeons, and hospital administrators can further optimize outcomes and foster a culture of accountability and safety.

Ethical considerations must remain at the forefront of all forensic evaluations. Ensuring objectivity, safeguarding patient confidentiality, and providing compassionate communication to affected parties are fundamental to upholding trust and professionalism in forensic medicine.

These recommendations aim to position forensic medicine as a cornerstone of modern healthcare systems, leveraging its potential to enhance diagnostic accuracy, reduce errors, and contribute to systemic reforms for better patient outcomes.

## References

1. Avci, A., Burcharth, J., Lunen, T. B., & Gögenur, I. J. U. f. L. (2019). Preoperative organ-specific assessment of risk of post-operative complications. *181*(11), V06180440-V06180440 .
2. Azimi, K., Honaker, M. D., Chalil Madathil, S., & Khasawneh, M. T. J. S .I. (2020). Post-operative infection prediction and risk factor analysis in colorectal surgery using data mining techniques: a pilot study. *21*(9), 784-792 .
3. Balch, J. A., Ruppert, M. M., Shickel, B., Ozrazgat-Baslanti, T., Tighe, P. J., Efron, P. A. , . . .Loftus, T. J. J. P. M. (2023). Building an automated, machine learning-enabled platform for predicting post-operative complications. *44*(2), 024001 .
4. Bertelsen, C. A., Neuenschwander, A. U., Jansen, J. E., Wilhelmsen, M., Kirkegaard-Klitbo, A., Tenma, J .R., . . . Jepsen, L. V. J. T. L. O. (2015). Disease-free survival after complete mesocolic excision compared with conventional colon cancer surgery: a retrospective, population-based study. *16*(2), 161-168 .
5. Bonde, A., Varadarajan, K. M., Bonde, N., Troelsen, A., Muratoglu, O. K., Malchau, H., . . . Sillesen, M. J. T. L. D. H. (2021). Assessing the utility of deep neural networks in predicting postoperative surgical complications: a retrospective study. *3*(8), e471-e485 .
6. Borshchevskaya, V., Denisova, A .,Todorov, S., Berezovsky, D., Shigeev, S., & Pigolkin, Y. I. J. S.-m. E. (2023). Forensic medical assessment of venous thromboembolic complications of mechanical injury of the lower limb after surgery. *66*(1), 35-38 .
7. Chelazzi, C., Villa, G., Vignale, I .,Falsini, S., Boni, L., & DE GAUDIO, A. R. J. A. A. S. (2015). Implementation and preliminary validation of a new score that predicts post-operative complications. *59*(5), 609-618 .
8. Danan, G., & Benichou, C. J. J. o. c. e. (1993). Causality assessment of adverse reactions to drugs—I. A novel method based on the conclusions of international consensus meetings: application to drug-induced liver injuries. *46*(11), 1323-1330 .
9. Dencker, E. E., Bonde, A., Troelsen, A., & Sillesen, M. J. B. o. (2024). Assessing the utility of natural language processing for detecting postoperative complications from free medical text. *8*(2), zrae020 .
10. Feld, S. I., Cobian, A. G., Tevis, S. E., Kennedy, G. D., & Craven, M. W. (2017). *Modeling the temporal evolution of postoperative complications*. Paper presented at the AMIA Annual Symposium Proceedings.
11. Feld, S. I., Tevis, S. E., Cobian, A. G., Craven, M. W., & Kennedy, G. D. J. S. (2016). Multiple postoperative complications: making sense of the trajectories. *160*(6), 1666-1674 .
12. Gibbs, J., Cull, W., Henderson, W., Daley, J., Hur, K., & Khuri, S. F. J. A. o. s. (1999). Preoperative serum albumin level as a predictor of operative mortality and morbidity: results from the National VA Surgical Risk Study. *134*(1), 36-42 .
13. Hammer, U., Blaas, V., Büttner, A., & Philipp, M. J. D. C. (2015). Autopsies for anatomical teaching and training in clinical forensic medicine. *86*, 1128-1131 .
14. Heinemann, A., Grabherr, S., Dedouit, F., Woźniak, K., Fischer, F., Wittig, H., . . . Imaging. (2017). The impact of multiphase post-mortem CT-angiography (MPMCTA) for investigating fatal outcomes of medical interventions. *8*, 38-44 .
15. Heinemann, A., & Vogel, H. J. A. o. P. A. (2016). Postmortem Angiography after invasive surgery. *327-341* .

16. Hopkins, B. S., Mazmudar ,A., Driscoll, C., Svet, M., Goergen, J., Kelsten, M., . . . neurosurgery. (2020). Using artificial intelligence (AI) to predict postoperative surgical site infection: a retrospective cohort of 4046 posterior spinal fusions. *192*, 105718 .
17. Jaison, K., & Muthukumaran, G. J. J. o. P. R. I. (2021). The Role of Serum Protein, Haemoglobin, and BMI as Predictors of Postoperative Morbidity and Mortality in Major Surgeries. *33(47B)*, 728-735 .
18. Meinarovich, P., Pautova, A., Zuev, E., Sorokina, E., Chernevskaya, E & ,Beloborodova, N. J. J. o. C. M. (2024). An Integrated Approach Based on Clinical Data Combined with Metabolites and Biomarkers for the Assessment of Post-Operative Complications after Cardiac Surgery. *13(17)*, 5054 .
19. Oleksandr, V. J. E. j. o. b., & sciences, I. (2016). Efficacy of titanium nickelide dilatator for improved drainage of surgery wounds in cases of mandibular bone fractures with inflammatory complications. (3), 11-12 .
20. Ranson, D. J. J. o. I., & Medicine. (2019). The Role of Patient-reported Outcome Measures in Post-operative Death Investigations. *26(4)*, 737-741 .
21. Saxton, A., & Velanovich, V. J. A. o. s. (2011). Preoperative frailty and quality of life as predictors of postoperative complications. *253(6)*, 1223-1229 .
22. Sethi, M. V. A., Zimmer ,J., Ure, B., & Lacher, M. J. J. o. P. S. (2016). Prospective assessment of complications on a daily basis is essential to determine morbidity and mortality in routine pediatric surgery. *51(4)*, 630-633 .
23. Sharma, V., Fadel, A., Tollefson, M. K., Psutka, S .P., Blezek, D. J., Frank, I., . . . Potretzke, A. M. J. J. o. U. (2024). Artificial intelligence-based assessment of pre-operative body composition is associated with early complications after radical cystectomy. 10.1097 .
24. Sitkowski, M., & Kenig, J. J. B .P. T. O. N. (2022). Evaluation of postoperative complications in the older population. *7(4)*, 288-295 .
25. Talmor, D., & Kelly, B. J. C. o. i. c. c. (2017). How to better identify patients at high risk of postoperative complications? , *23(5)*, 417-423 .