



Assessment of pulmonary embolism mortality in trauma orthopaedic patients and the evaluating role of nursing staff in the early detection of thrombo-embolic complications – literature review and original research

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Abstract

Introduction and Objective. Venous thromboembolism (VTE), which includes pulmonary embolism (PE) and deep vein thrombosis (DVT), is a critical complication in orthopaedic surgery, significantly contributing to patient mortality. The review evaluates the impact of nursing knowledge and engagement in the early detection of thromboembolic complications and mortality rates in trauma-orthopaedic wards, emphasizing the importance of the education of nurses and VTE prophylaxis.

Review Methods. A systematic review was conducted using Google Scholar and PubMed, focusing on articles published between 2013–2023. Studies assessing nurses' knowledge and practices regarding VTE, using surveys, questionnaires, and patient observations were included. Data from 276 orthopaedic patients hospitalized between 2012–2020 were also analyzed.

Brief description of the state of knowledge. The review indicates that thromboembolic complications are a leading cause of mortality among orthopaedic patients. Nursing education and awareness in VTE prevention vary significantly. Standardized risk assessment tools, such as the Autar and Wells scales, are crucial for early VTE detection. The nurse-to-patient ratio (NTP) is critical, with better NTP ratios correlating with improved outcomes. The data showed significant differences in mortality rates between patients with confirmed PE and those without, highlighting the need for continuous monitoring and advanced diagnostic techniques.

Summary. The review underscores the crucial role of nursing staff in the early detection and prevention of VTE in orthopaedic patients. Despite advancements in prophylaxis, the quality of nursing education and adherence to VTE prevention protocols remain pivotal. Improving nurse training and optimizing the NTP ratio in hospitals are essential for reducing VTE-related mortality.

Key words

pulmonary embolism, venous thromboembolism, trauma surgery, orthopaedics, mortality, nursing care

INTRODUCTION AND OBJECTIVE

Venous thromboembolism (VTE), which includes pulmonary embolism (PE) and deep vein thrombosis (DVT), is one of the most serious consequences of orthopaedic surgery [1, 2]. Extensive surgical procedures, such as hip and knee arthroplasty or high-energy traumatic injuries, including

pelvic fractures and long bone fractures, are associated with a significant risk of thromboembolic complications which, according to numerous scientific reports, often lead to fatal outcomes [2, 3, 4, 5]. In cases where there is significant intervention in the musculoskeletal system, mortality can occur in up to 7% of patients [3, 6].

VTE is the most common preventable cause of death in high-risk hospital patients [7]. This indicates that not all patients hospitalized in orthopaedic departments receive basic thromboprophylaxis, or at least it is not applied to the extent required by the patient's needs. The incidence of VTE among patients receiving thromboprophylaxis ranges from

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1.3% – 10%, whereas without preventive measures, it can reach 40% – 60% [8]. Properly planned thromboprophylaxis is of immense importance among patients undergoing high-risk orthopaedic surgeries aimed at minimizing the risk of symptomatic VTE and its potential life-threatening consequences [4, 9, 10].

It is essential to note that despite the implementation of appropriate preventive strategies, fatal cases of VTE are still recorded. This raises the question: why, despite the improvement of mechanical and pharmacological preventive methods, is mortality among patients undergoing orthopaedic procedures still disproportionately high? The causes can be traced to the non-specific symptoms of VTE, which, as the literature indicates, can be easily overlooked [11]. Identifying individuals at risk, assessing these patients for early signs and symptoms, and establishing preventive measures to minimize the impact of existing factors or halt their development, are fundamental elements of nursing care [12].

OBJECTIVE

The aim of this study is to evaluate the quality of preventive methods by analyzing research and review articles that demonstrate the statistically higher effectiveness of nurses who are adequately trained and work in orthopaedic wards, compared to those without appropriate education. This effectiveness is determined based on their knowledge and practical skills in implementing thromboprophylaxis. Specifically, the study aims to highlight the critical role that well-trained nurses play in reducing the incidence of thromboembolic complications, such as pulmonary embolism and deep vein thrombosis, in patients undergoing high-risk orthopaedic surgeries.

In order to substantiate the findings from the literature, the authors conducted their own analysis of the most frequent causes of mortality in orthopaedic wards. This analysis is based on our own data, which presents the percentage of orthopaedic hospitalizations resulting in death due to thromboembolic complications. Additionally, the available literature was reviewed to provide a comprehensive context for the findings.

The study also aims to show that thromboembolic incidents are currently the leading cause of mortality among the studied patient group. By comparing the outcomes of patients cared-for by well-trained nurses versus those cared for by less specialized staff, the intention is to underscore the importance of specialized training and its direct impact on patient outcomes. It is hoped that the review advocates improved training programmes and the implementation of standardized preventive measures in orthopaedic departments to reduce the high mortality rates associated with thromboembolic events.

REVIEW METHODS

A systematic review was conducted of the literature to identify current studies on the quality of nursing care in the prevention of venous thromboembolism (VTE). For this purpose, databases such as Google Scholar and PubMed were utilized to search for articles published between 2013 – 2023.

The articles included in the review assessed the knowledge and practice of nurses regarding VTE, its risk factors and preventive measures, using surveys, questionnaires, and patient health observations.

To justify the necessity for researching the effectiveness of nursing VTE prevention, the most common causes of mortality in orthopaedic wards were also analyzed. This analysis was based on own results, which present the percentage of orthopaedic hospitalizations ending in death due to thromboembolic complications. Additionally, a review of the literature was conducted which included original articles, review articles, and case reports from the past five years retrieved from Google Scholar and PubMed that describe the impact of thromboembolic complications on the mortality of patients hospitalised as orthopaedic patients.

The study was approved by the Ethics Committee of the Medical University in Lublin, Poland (dated 31.01.2019) and included 276 orthopaedic patients admitted to hospital in Lublin between 2012 – 2020. The patients were admitted both urgently and electively, with an equal distribution by gender (138 women and 138 men), with their clinical presentation indicating a suspicion of pulmonary embolism (PE). Based on this suspicion, they were referred for imaging diagnostics in the form of a CT pulmonary angiogram. Statistical analysis was performed based on the results from their medical records.

CURRENT STATE OF KNOWLEDGE AND ORIGINAL RESULTS

The role of nursing care – a review of the literature. The criteria for inclusion in the literature review were met by five original studies, with the oldest published in 2014 and the most recent in 2023. Despite the 10-year time span, the results of these studies exhibited consistency in their conclusions (Tab. 1) and studies collectively underscored the critical role of nursing education and training in the prevention of venous thromboembolism (VTE). In four of the studies, however, the authors demonstrated that nurses working in orthopaedic wards were generally insufficiently trained in VTE prevention. This insufficient training resulted in limited knowledge regarding thromboembolic risk factors and a low frequency of implementing effective thromboprophylactic measures [13, 14, 15, 16]. The findings suggest a significant gap in the continuing education of nursing staff, which directly impacts patient outcomes.

One particularly noteworthy study, ‘Analysis of Risk Factors for Postoperative Lower Extremity Deep Venous Thrombosis and its Treatment and Nursing’, provided compelling evidence that the implementation of targeted nursing interventions for VTE prevention led to significant clinical improvements. These interventions in the study group resulted in the alleviation of hypercoagulability symptoms, a reduction in inflammation, and an overall improvement in patient comfort. Such outcomes directly correlated with a decreased risk of developing VTE, thereby highlighting the importance of specialized nursing care and training [17].

The findings from these studies emphasize the need for enhanced training programmes for nurses in orthopaedic wards to ensure they are equipped with the necessary knowledge and skills to effectively prevent thromboembolic complications. This approach is crucial for improving patient safety and reducing the incidence of VTE-related mortality

Table 1. Latest literature on thromboembolism prevention among nursing staff

Title and date	Authors	Methods (A) methods (B) scopes	Study groups (n)	Results and conclusions
1. Evaluation of hospital nurses' perceived knowledge and practices of venous thromboembolism assessment and prevention (2014) [13]	Lee JA, Grochow D, Drake D, Johnson L, Reed P, van Servellen G.	(A) Online survey (B) Assessment of own knowledge about VTE, frequency of assessment of patients for VTE, self-efficacy in applying VTE prevention	n = 221	1) The most common assessment of general knowledge regarding VTE risk assessment is 'good' (44%) and 'sufficient' (28%). 2) The lowest rated competence was one's own ability to accurately assess the risk of VTE. 3) Greater knowledge about VTE was associated with more frequent VTE risk assessment and self-efficacy for preventive care.
2. Knowledge and practices of nurses on deep vein thrombosis risks and prophylaxis: A descriptive cross sectional study (2018) [14]	Al-Mugheed KA, Bayraktar N.	(A) Questionnaire (B) General knowledge about the subject of VTE – risk factors and prevention	n = 165	1) 97 (58.8%) of the respondents had never previously received education on VTE; 8 (41.2%) of the respondents had received education on VTE; only 24 (35.3%) at the university level. 2) High results regarding general knowledge about VTE (average 5/6 correct answers). 3) Low level of knowledge regarding: risk factors (on average 13/20 responses), preventive measures (on average 1/8 responses) and poor practices in the prevention of VTE.
3. Chinese orthopaedic nurses' knowledge, attitude and venous thromboembolic prophylactic practices: A multicentric cross-sectional survey (2021) [15]	Wang Y, Wu XJ, Ma YF, Xu Y, Wang XJ, Zhu C, Cao J, Jiao J, Liu G, Li Z, Liu Y, Zhu LY.	(A) Questionnaire (B) Attitude and knowledge about VTE prevention, multicentre study	n = 3903	1) 98% of respondents strongly or somewhat agreed that VTE prevention is a key and important part of nursing care. 2) 22% of respondents strongly or somewhat disagreed with the relationship between VTE and low quality of nursing care. 3) Nurses' mean knowledge was 6.59 ± 1.574 with a maximum score of 9.
4. Nursing Care and Barriers for Prevention of Venous Thromboembolism in Total Knee and Hip Arthroplasty Patients: A Qualitative Study (2023) [16]	Al-Mugheed K, Totur Dikmen B, Bayraktar N, Farghaly Abdelallem SM, Ahmed Alsenany S.	(A) Questionnaire (B) Nursing practice in VTE prevention and barriers encountered during VTE prevention in patients after total knee and hip arthroplasty	n = 10	1) Education is key to improving the effects of nursing work. Educational institutions must sufficiently prepare nurses to work in clinical settings by creating clinical nurse specialization programmes and postgraduate programmes.
5. Analysis of Risk Factors for Postoperative Lower Extremity Deep Venous Thrombosis and its Treatment and Nursing (2022) [17]	Liu H, Peng Y.	(A) retrospective analysis conducted from July - December 2021 (B) Analysis of factors related to lower extremity deep venous thrombosis (LEDVT) in the studied patients, using a logistic regression model with the assessment of laboratory parameters	n = 268 (patients)	1) Hypertension, paralysis, central venous catheterization of the lower limbs and duration of bed rest influence postoperative LEDVT independently ($p < 0.05$). 2) After nursing intervention, coagulation function and inflammatory response improved in all groups ($p < 0.05$).

Mortality in pulmonary embolism – a literature review and own findings. Statistical analysis based on the medical records of the patients included in this review shows that pulmonary embolism (PE) was excluded in 160 out of 276 patients (84 women and 76 men) using imaging diagnostics, while it was confirmed in 116 out of 276 patients (54 women and 62 men). The average age in the first group was 68.9 years, whereas in the second group it was 71.6 years. The mortality rate in the studied group was quite significant. In the group of patients with confirmed PE, it was 8.62% (10 out of 116).

Table 2. Ratio of total hospitalizations to hospitalizations ending in patient death.

	Total No. of hospitalizations	No. of hospitalizations ending in patient death	% of hospitalizations (to 0.1%)
Confirmed Pulmonary Embolism	116	10	8,6%
Unconfirmed Pulmonary Embolism	160	8	5%
Total	276	18	6,5%

Due to the long observation period based solely on available medical records and imaging studies, it cannot be ruled out that other factors also significantly influenced some of the deaths. For comparison, in the group where PE was excluded, the mortality rate was 5%. This means that among the 160 patients with PE excluded, based on imaging studies, eight deaths were recorded. These findings are crucial as they underscore the high risk associated with PE in orthopaedic patients, and the importance of accurate and timely diagnosis. Additionally, the slight difference in average age between the groups (68.9 years in those without PE and 71.6 years in those with confirmed PE) suggests that older age may be a contributing factor to the increased risk and mortality associated with PE. These results align with the majority of reports in the literature, reinforcing the need for continuous monitoring and advanced diagnostic techniques in the management of orthopaedic patients (Tab. 3). Moreover, the consistent alignment of the obtained results with existing literature highlights the reliability of the presented review and the broader applicability of the results. This comprehensive analysis emphasizes the necessity for improved preventive strategies and the education of healthcare providers to effectively mitigate the risks of thromboembolic complications in the high-risk patient groups.

SUMMARY

VTE is one of the most serious complications in orthopaedic surgery [29, 30, 31, 32]. The presented review studies and analyses aimed to demonstrate that, despite the current level of knowledge about VTE and the high level of research on its effective prevention methods in perioperative patients, the overarching problem is the underestimation of the crucial role of education and the implementation of developed VTE prophylaxis models among nursing staff. This issue is particularly alarming when considering the mortality rates among orthopaedic patients.

In 2020, Santana et al. conducted a literature review that noted a significant decrease in the average postoperative mortality rate from 1950 to 2016 among patients undergoing hip or knee replacement surgery. Mortality was estimated at 1.15% (<1980) and 0.24% (>2011) [33]. Factors contributing to this improvement included increased awareness of proper thromboembolic risk assessment and the implementation of appropriate thromboprophylactic measures for high-risk patients [34, 35, 36]. The complexity of balancing thromboprophylactic protection and the risk of bleeding during pharmacotherapy continues to pose a challenge for clinicians, necessitating a selective approach for different patient groups [37, 38].

Excluding non-modifiable factors, such as patient age and the size and type of surgical procedure, it can be concluded that nursing staff, who have the most contact with patients in the ward, play a fundamental role in improving clinical practice outcomes [39]. Their involvement in patient education and vigilant monitoring is critical in the effective prevention of VTE and reducing associated mortality rates.

Revolutionary in the early detection of VTE, which also marked the beginning of a decline in mortality in the aforementioned population, were the principles for assessing patients at risk of developing VTE published by Autar in 1994 and the Wells score published in *The Lancet* the following year [40, 41]. These risk assessment scales provided less qualified medical personnel with tools for continuous monitoring, risk assessment of thrombosis, and patient screening. This resulted in referring only truly at-risk patients for specialized examinations (Doppler ultrasound). What then, is the cause of the persistently high mortality rates due to VTE in orthopaedic wards, nearly 30 years after the introduction of the Autar and Wells scales, despite the advancements in the effectiveness of pharmacological and mechanical preventive methods for VTE?

Certainly, attention must be given to the quality of services provided by hospital staff, particularly nurses, who have the most contact with patients. Numerous studies based on personal questionnaires conducted with licensed nursing staff working in hospitals have shown that the quality of training, awareness in decision-making, and knowledge of guidelines vary and are often at an unsatisfactory level [13, 14, 15, 16, 17].

Wang Y et al. report that 25% of surveyed nurses had virtually no knowledge of VTE, while only 44% rated their knowledge as good. The authors unequivocally indicated the necessity for professional training, which hinders early recognition of VTE symptoms and the implementation of appropriate prophylaxis [15]. In similar analyses from the USA, over 70% of respondents rated the effectiveness of their actions as good. Failures in clinical practice seemed to be due to limitations in the healthcare system, such as reimbursement and overall treatment funding [13]. The most striking and extreme examples were cited for discussion. A detailed literature review can be found in Table 1. New insights into the differences in study results among nurses are provided by a 2020 study conducted by Yuchi Shen et al., whose analysis revealed that in large Chinese hospitals, only five nurses are assigned to 44 patients [42]. The average Nurse-to-Patient (NTP) ratio is 1:8, although in wards where patients are particularly at risk for thromboembolic complications, it is much higher, such as 1:34 in Oncology Wards.

Table 3. Mortality Rate of Orthopedic Patients Due to Pulmonary Embolism Complications

Title	Authors and date	Study population characteristics	% of deaths in the VTE group (to 0.1%)	% of deaths in the non-VTE group (to 0.1%)
What are the incidence and risk factors of in-hospital mortality after venous thromboembolism events in total hip and knee arthroplasty patients? [6].	Shahi A, Bradbury TL, Guild GN, et al. (2018)	1,805,621 patients underwent hip or knee replacement surgery; confirmed VTE among 16,838 patients (0.9%).	1,203/16,838 (7.1%) during hospital stay.	5 441/1 788 783 (0.30%) during the stay in hospital
The risk of venous thromboembolism in surgically-treated hip fracture: A retrospective cohort study of 5184 patients [18].	Beauchamp-Chalifour P, Belzile ÉL (2022)	5,184 patients underwent surgery following a hip fracture; confirmed VTE among 144 patients (2.8%).	22/144 (15.3%) within 3 months of the procedure.	406/5040 (8.1%) within three months of the procedure
Increased Morbidity With Diagnosis and Treatment of Pulmonary Embolism After Total Joint Arthroplasty: A Matched Control Analysis of 30,000 Patients [19].	Reddy GB, Ovidia JE, Yakkanti RR, et al. (2022)	8,634,038 patients who underwent hip or knee replacement surgery; confirmed PE among 30 281 patients(0.4%)	1,030/30,281 (3.4%) during hospital stay.	(0.1%) during the stay in hospital
Venous thromboembolism after hospital discharge in pelvic and acetabular fracture patients treated operatively [20].	Dwyer EP, Moed BR (2019)	13,589 patients underwent surgery after a pelvic ring fracture or hip acetabulum fracture; confirmed VTE among 113 patients (0.8%)	5/113 (4.4%) >35 days from the end of hospitalization	no deaths were recorded >35 days after the end of hospitalization
High Risk of Symptomatic Venous Thromboembolism After Surgery for Spine Metastatic Bone Lesions: A Retrospective Study [21].	Groot OQ, Ogink PT, Paulino Pereira NR, et al. (2019)	637 patients who underwent spine surgery due to metastatic cancer; confirmed VTE among 72 patients (11.0%).	8/72 (11.1%) within a year of surgery.	no deaths were reported within a year of surgery
Prognosis of venous thromboembolism in orthopaedic surgery or trauma patients and use of thromboprophylaxis [22].	Gutiérrez Guisado J, Trujillo-Santos J, Arcelus JL, et al. (2018)	61,789 patients, including: those who underwent hip or knee replacement surgery, after a hip fracture, after less invasive orthopaedic procedures (e.g. arthroscopy), and patients with injuries who did not require surgical treatment; confirmed VTE among 4,569 patients (7.4%).	30/4,569 (0.66%) within 90 days of surgery.	171/ 57 220 (0.3%) within 90 days of surgery
Venous thromboembolism in patients hospitalized for hip joint replacement surgery [23].	Keller K, Hohobm L, Barco S, et al. (2020)	1,885,839 patients underwent hip arthroplasty; confirmed VTE among 11,554 patients (0.6%).	770/11,554 (6.7%) during the stay in hospital	5074/1 874 285 (0.3%) during hospital stay.
Incidence and Risk Factors for Complications and Mortality After Vertebroplasty or Kyphoplasty in the Osteoporotic Vertebral Compression Fracture-Analysis of 1,932 Cases From the American College of Surgeons National Surgical Quality Improvement [24].	Kim HJ, Zuckerman SL, Cerpa M, et al. (2022)	1,932 patients who underwent vertebroplasty or kyphoplasty after osteoporotic vertebral fractures; confirmed VTE among 27patients (1.4%).	1/27 (3.7%) within 30 days of surgery	39/1,905 (2.0%) within 30 days of surgery.
Thromboembolic complications among multiple injured patients with pelvic injuries: identifying risk factors for possible patient-tailored prophylaxis [25].	Kirchner T, Lefering R, Sandkamp R, et al. (2021)	10,634 patients with an injury to the pelvis or hip joint acetabulum; confirmed VTE among 521 patients (4.9%).	89/521 (17.1%) during hospital stay.	486/10,113 (4.8%) during hospital stay.
Evaluation of venous thromboembolic complications in patients operated on for pelvic fracture [26].	Ostrowka C, Bonhomme S, Jouffroy P, et al. 2018)	120 patients after surgery of a fracture in the pelvis or hip acetabulum; VTE was confirmed in 6 patients (5%)	1/6 (16.7%) intra-operative PE	No deaths recorded during follow-up.
Symptomatic Venous Thromboembolism After Achilles Tendon Rupture: A Nationwide Danish Cohort Study of 28,546 Patients With Achilles Tendon Rupture [27].	Pedersen MH, Wahlsten LR, Grønberg H, et al. (2019)	28,546 patients after Achilles tendon rupture; VTE was confirmed among 389 patients (1.36%).	12/389 (3.1%) during 180 days of follow-up	No deaths recorded during 180 days of follow-up.
CT pulmonary angiography in lower limb arthroplasty: A retrospective review of 11 249 patients over 11 years [28].	Karayiannis PN, Hill JC, Stevenson C, et al. (2018)	11,249 patients who underwent hip or knee replacement surgery; PE was confirmed among 86 patients (0.8%)	9/86 (10.5%) during observation period	22/11163 (0.2%) during observation period.

In the light of guidelines published by the British National Institute for Health and Care Excellence (NICE), which state that 'a nurse should be responsible for no more than eight patients', these data are alarming [43]. In the USA, where the majority of nursing staff rate the effectiveness of their actions as good, the average NTP ratio was 1:4 in 2004 [44]. Despite

studies conducted in Poland on the correlation between the number of patients per nurse, their education, type of healthcare system, quality of healthcare services and the incidence of thromboembolic complications, it seems evident that attempts must be made to adopt Western standards in Polish hospitals. Currently, the simplest, most cost-effective,

and best-researched solution appears to be the implementation of risk assessment scales for thromboembolism, such as the previously-mentioned Autar and Wells scales, as well as such newer scales as the Padua scale, the modified Caprini risk assessment model, and the Geneva scale, with an emphasis on their proper and diligent implementation by hospital staff in daily practice [40, 45]. Additionally, efforts should be made to achieve an NTP ratio in Poland similar to that in the USA – 1:4 [43].

The sources analyzed for this review indicate a consistent conclusion: thromboembolic complications are a leading cause of mortality among orthopaedic patients, highlighting the need to enhance the education of nursing staff caring for at-risk patients. This education should focus on early symptoms and patient monitoring.

Despite the lack of specific analyses, the correlation between the nurse-to-patient ratio (NTP), the ability to accurately assess thromboembolic risk, self-awareness of knowledge, and the incidence of VTE and patient survival seems significant. The greatest challenge for hospital management is optimizing the NTP ratio to meet NICE guidelines. Special attention should be given to wards treating patients with an increased risk profile for thromboembolic events. This underscores the necessity of raising awareness about effective preventive measures and promoting the need for the continuous education of nursing staff.

Professional nursing prophylaxis utilizing tools such as risk assessment scales for early VTE detection, along with pharmacological thromboprophylaxis, has a real impact on reducing mortality among high-risk patients. Due to the very limited number of studies currently available, further research is needed in this area.

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