Original Article: Evaluation of the Effects of Dexmedetomidine in Controlling Intraoperative Bleeding During Femoral Head Intramedullary Nailing in Trauma Patients

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Citation *M Saiarsarai,* ***Evaluation of the Effects of Dexmedetomidine in Controlling Intraoperative Bleeding During Femoral Head Intramedullary Nailing in Trauma Patients,*** *EJCMPR.* 2024; 3(5): 202-213.

https://doi.org/EJCMPR/202412229

Article info:
Received: **20 October 2024**
Accepted: **01 January 2025**
Available Online:
ID: EJCMPR-2501-1269
Checked for Plagiarism: **Yes**
Peer Reviewers Approved by:
Dr. Frank Rebout
Editor who Approved Publication:
Dr. Frank Rebout

Keywords:
Dexmedetomidine, blood loss, femoral intramedullary nailing, trauma surgery

A B S T R A C T

Introduction: Trauma patients undergoing femoral intramedullary nailing surgery often experience significant blood loss, leading to the need for effective management strategies. Dexmedetomidine, an alpha-2 adrenergic agonist, has shown promise in reducing intraoperative blood loss and stabilizing hemodynamics, making it a potential adjunct in trauma surgeries.

Methods: In this double-blind, randomized controlled trial, 60 trauma patients undergoing femoral intramedullary nailing were randomly assigned to either the dexmedetomidine (n = 30) or control (n = 30) group. The dexmedetomidine group received an infusion of 0.6 μg/kg for 10 minutes before induction, followed by a maintenance dose. Intraoperative blood loss, transfusion requirements, heart rate, and systolic blood pressure were assessed. Statistical analyses were performed using independent t-tests and chi-square tests, with p-values < 0.05 considered significant.

Results: The dexmedetomidine group exhibited significantly lower intraoperative blood loss (p = 0.001) and more stable hemodynamic parameters, including heart rate and systolic blood pressure (p < 0.05). The need for blood transfusions was lower in the dexmedetomidine group, although not statistically significant (p = 0.073). Recovery time was also significantly shorter in the dexmedetomidine group (p = 0.002).

Conclusion: Dexmedetomidine significantly reduced intraoperative blood loss and stabilized hemodynamic parameters in trauma patients undergoing femoral intramedullary nailing surgery. Its potential benefits for trauma surgery include reduced transfusion needs and faster recovery times.

Introduction

In trauma surgery, controlling intraoperative bleeding is critical to the success of the procedure and the overall outcome for the patient. One of the most challenging areas where blood loss can be substantial is in femoral fracture surgeries, especially those involving femoral head intramedullary nailing [1-3]. These fractures, often caused by high-energy trauma

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such as motor vehicle accidents or falls from significant heights, can result in extensive hemorrhage due to the large vascular supply in the femoral region [4].

In trauma patients, particularly those in a compromised state, excessive blood loss can lead to life-threatening complications such as hypovolemic shock, multi-organ failure, or even death if not properly managed. Therefore, controlling blood loss during surgery is essential to reducing mortality and improving recovery times [5].

In addition to the inherent challenges posed by femoral head fractures, trauma patients are often at a higher risk of complications due to factors such as preexisting comorbidities, hypovolemia, and hemodynamic instability. The need for effective surgical techniques and pharmacological interventions to reduce blood loss during surgery is paramount. Dexmedetomidine, an alpha-2 adrenergic agonist, has gained attention in the medical community for its multifaceted effects during surgery, including sedation, analgesia, and, importantly, it's potential to reduce blood loss. Dexmedetomidine works primarily by acting on the central nervous system, selectively binding to alpha-2 receptors in the brainstem, which results in sedation and analgesia without the need for high doses of other anesthetics or opioids [6].

Its effects on the autonomic nervous system also extend to cardiovascular parameters, where it can help stabilize blood pressure and heart rate during surgery. The ability of dexmedetomidine to cause vasoconstriction, particularly in smaller blood vessels, can contribute to a reduction in blood flow to the surgical site, potentially decreasing the amount of blood lost during surgery [3].

This makes it an attractive option for surgeries like femoral head intramedullary nailing, which involves complex and often extensive dissection around the femoral artery and other major vessels.

In trauma surgeries, blood loss is a significant concern not only due to the direct trauma to blood vessels but also because trauma patients often have impaired clotting mechanisms, possibly due to preexisting medical conditions, medications, or the severity of the injury. Excessive intraoperative bleeding can lead to the need for blood transfusions, which introduce additional risks of infection, transfusion reactions, and other complications. Reducing the need for transfusions and controlling blood loss during surgery is therefore of utmost importance in the trauma population.

While there is a growing body of literature on the use of dexmedetomidine in various surgical settings, including orthopedic and trauma surgeries, the effects of dexmedetomidine in controlling blood loss specifically during femoral head intramedullary nailing have not comprehensively studied.

Previous studies have suggested that dexmedetomidine can reduce intraoperative blood loss in a variety of surgical procedures, including spine surgery, abdominal surgery, and even cardiac surgeries. These studies have highlighted the potential of dexmedetomidine to maintain hemodynamic stability, reduce opioid consumption, and decrease the need for vasopressors, all of which are beneficial in the trauma patient population [2].

In trauma patients undergoing femoral head intramedullary nailing, the complexity of the surgery and the proximity of critical vessels to the surgical field increase the risk of significant blood loss. The femoral artery, which is one of the main suppliers of blood to the lower extremities, lies near the femoral head and injured during the procedure. Furthermore, the surrounding muscle tissue and bone marrow contain extensive vascular networks, which may lead to additional bleeding during the

process of reducing and stabilizing the fracture. As such, any intervention that can reduce bleeding in this setting is highly valuable.

One potential mechanism by which dexmedetomidine could reduce blood loss during femoral head intramedullary nailing is through its ability to cause vasoconstriction. By stimulating alpha-2 adrenergic receptors, dexmedetomidine inhibits the release of norepinephrine, leading to decreased sympathetic outflow and ultimately resulting in vasoconstriction [3].

This effect could reduce blood flow to the surgical site, minimizing the amount of bleeding. Additionally, dexmedetomidine's ability to maintain stable blood pressure and reduce heart rate could prevent hemodynamic instability, which is often associated with excessive bleeding [4].

Beyond its effects on blood loss, dexmedetomidine may offer additional benefits for trauma patients undergoing femoral head surgery. For example, its sedative and analgesic properties may reduce the need for opioid medications, which can have adverse effects such as respiratory depression and increased risk of complications in trauma patients [5].

This is particularly important in a patient population that may already be at risk for respiratory complications due to the nature of their injuries. By providing effective sedation and analgesia, dexmedetomidine may allow for a smoother intraoperative course and better postoperative recovery [6-8].

There is also the potential for dexmedetomidine to improve postoperative outcomes in trauma patients undergoing femoral head surgery. By reducing the amount of blood lost during the procedure, patients may experience fewer complications such as hypovolemic shock, need for transfusions, and infection [8-10].

Additionally, the maintenance of stable hemodynamics during surgery could result in fewer postoperative complications, leading to improved recovery times and better overall outcomes [11].

Despite the promising potential of dexmedetomidine in controlling blood loss during trauma surgeries, its use in femoral head intramedullary nailing specifically has not thoroughly investigated [12].

This gap in the literature presents an opportunity for research to explore the effects of dexmedetomidine on blood loss, hemodynamic stability, and postoperative recovery in this patient population. The aim of this study is to evaluate the effects of dexmedetomidine on controlling intraoperative bleeding during femoral head intramedullary nailing in trauma patients. Specifically, the study will focus on the amount of blood loss during the procedure, the need for blood transfusions, and any changes in hemodynamic parameters, such as blood pressure and heart rate [13].

The study will also assess postoperative recovery, including pain management, the length of stay in the hospital, and any complications associated with the use of dexmedetomidine [14-16].

The hypothesis of this study is that dexmedetomidine will reduce intraoperative bleeding during femoral head intramedullary nailing, improve hemodynamic stability, and enhance postoperative recovery. By evaluating these factors, this research will provide valuable insights into the potential benefits of dexmedetomidine in trauma surgery and may contribute to the optimization of anesthetic strategies in trauma patients undergoing femoral head surgery [17-19].

In conclusion, intraoperative bleeding is a significant concern during trauma surgeries, particularly in femoral head intramedullary nailing, where the potential for substantial

blood loss is high [20-22]. Dexmedetomidine has shown promise in reducing blood loss and improving hemodynamic stability in other surgical settings, and its use in trauma surgeries warrants further investigation. This study aims to evaluate the effects of dexmedetomidine in controlling blood loss during femoral head intramedullary nailing in trauma patients, and its results may have important implications for improving surgical outcomes in this challenging patient population [23-25].

Materials and Methods

Study Design: This was a randomized, double blind, placebo-controlled clinical trial designed to evaluate the effects of dexmedetomidine in controlling intraoperative bleeding during femoral head intramedullary nailing surgery in trauma patients.

Sample Size and Sampling: 60 patients were included in this study. The sample size was determined based on power calculations to detect significant differences in intraoperative bleeding and hemodynamic parameters between the intervention and control groups. Patients recruited consecutively from those undergoing femoral head intramedullary nailing surgery for trauma at our institution. Inclusion criteria included adult patients aged between 18 and 65 years with a traumatic femoral head fracture, American Society of Anesthesiologists (ASA) classification I-III, and consent to participate in the study. Exclusion criteria included patients with known hypersensitivity to dexmedetomidine, significant cardiovascular or respiratory diseases, pregnancy or lactation, significant comorbidities such as liver or renal failure, and those on anticoagulant therapy.

Randomization and Blinding: Patients randomly assigned to one of two groups: the intervention group (dexmedetomidine) or the control group (placebo). Randomization achieved using a computer-generated randomization list, ensuring an equal allocation ratio between the two groups. The randomization process conducted by an independent researcher not involved in patient care or assessment. Both patients and the surgical team blinded to group allocation (double-blind design) to minimize bias and ensure objective outcome assessment.

Methods: The intervention group received an intravenous infusion of dexmedetomidine at a dose of 0.5 μg/kg over 10 minutes prior to anesthesia induction, followed by a continuous infusion of 0.2 μg/kg/hour during surgery. The control group received a placebo infusion of normal saline. Anesthesia administered according to standard institutional protocols, and all patients underwent femoral head intramedullary nailing surgery under general anesthesia. Hemodynamic parameters, including blood pressure, heart rate, and oxygen saturation, continuously monitored throughout the procedure.

Variables: The primary outcome of the study was the amount of intraoperative blood loss, measured by the volume of blood collected in the surgical drapes and suction containers. Secondary outcomes included the need for blood transfusion, changes in hemodynamic parameters (heart rate, systolic and diastolic blood pressure), the incidence of perioperative complications (such as arrhythmias and hypotension), and the postoperative recovery time (measured by the time to regain consciousness and ability to perform basic activities). Pain intensity scores were also assessed using the Visual Analog Scale (VAS) at 1, 6, and 24 hours postoperatively.

Statistical Analysis: Data were analyzed using SPSS version 22 (IBM Corp, Armonk, NY). Descriptive statistics used to summarize the demographic and baseline characteristics of the patients. The Shapiro-Wilk test used to assess the normality of the data. For

comparisons between the two groups, independent t-tests or Mann-Whitney U tests used for continuous variables, depending on the distribution of the data. Categorical variables compared using the chi-squared test. A p-value of less than 0.05 considered statistically significant. Additionally, multivariate analysis conducted to adjust for potential confounding factors, such as age, sex, and baseline comorbidities.

Ethical Considerations: The study conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All patients provided written informed consent prior to participation in the study. Ethical approval obtained from the Ethics Committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1400.921), and the study registered in the Iranian Clinical Trial Registration System (IRCT20200910048678N2). Patient confidentiality strictly maintained, and all data anonymized for analysis. Patients were free to withdraw from the study at any time without any consequences for their medical care.

Results

In this study, 60 trauma patients randomly assigned into two groups: the intervention group (dexmedetomidine) and the control group (placebo), with 30 patients in each group. The primary outcome was the amount of intraoperative blood loss, and secondary outcomes included hemodynamic stability (heart rate, blood pressure), the need for blood transfusion, and perioperative complications.

The demographic characteristics of the patients, including age, gender, and comorbidities, were similar between the two groups. There were no statistically significant differences between the groups regarding age, sex distribution, or comorbid conditions such as hypertension or diabetes.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population

Characteristic	Dexmedetomidine Group (n=30)	Control Group (n=30)	p-value
Age (years)	45.36 ± 7.65	46.12 ± 8.01	0.614
Male (%)	19 (63.33%)	18 (60.00%)	0.812
Hypertension (%)	5 (16.67%)	6 (20.00%)	0.742
Diabetes Mellitus (%)	4 (13.33%)	5 (16.67%)	0.799
ASA Class I (%)	21 (70.00%)	20 (66.67%)	0.801
ASA Class II (%)	9 (30.00%)	10 (33.33%)	0.745

The comparison shows no significant differences in baseline characteristics, indicating that both groups were similar at the start of the study.

This table presents the comparison of intraoperative blood loss between the two groups. The dexmedetomidine group demonstrated a significantly lower amount of blood loss during surgery compared to the control group.

Table 2: Intraoperative Blood Loss between Groups

Group	Mean Blood Loss (mL) ± SD	p-value
Dexmedetomidine Group	150.32 ± 32.45	0.013
Control Group	203.67 ± 41.23	

Intraoperative blood loss significantly reduced in the dexmedetomidine group, suggesting the beneficial effect of dexmedetomidine in controlling bleeding during surgery.

This table compares the heart rate and systolic blood pressure between the two groups during the surgery. The results indicate that the dexmedetomidine group had more stable hemodynamic parameters, with a significant difference in systolic blood pressure (SBP) and heart rate compared to the control group.

Table 3: Hemodynamic Parameters During Surgery

Group	Heart Rate (beats/min) ± SD	Systolic BP (mmHg) ± SD	p-value
Dexmedetomidine Group	76.45 ± 6.15	120.45 ± 7.12	0.045
Control Group	82.73 ± 7.89	130.89 ± 9.25	

The dexmedetomidine group exhibited a more stable heart rate and lower systolic blood pressure during surgery, which attributed to the sedative and sympatholytic effects of dexmedetomidine.

This table summarizes postoperative outcomes, including the need for blood transfusion and any complications that arose after surgery. The incidence of complications was similar in both groups, with no significant differences observed.

Table 4: Postoperative Outcomes and Complications

Outcome	Dexmedetomidine Group (n=30)	Control Group (n=30)	p-value
Blood Transfusion Required (%)	4 (13.33%)	9 (30.00%)	0.073
Postoperative Complications (%)	2 (6.67%)	3 (10.00%)	0.699
Time to Full Recovery (hours)	25.12 ± 3.01	28.54 ± 3.42	0.022

The dexmedetomidine group required fewer blood transfusions, although the difference did not reach statistical significance ($p = 0.073$). Moreover, the time to full recovery was significantly shorter in the dexmedetomidine group ($p = 0.022$), suggesting faster recovery postoperatively.

Discussion

This study aimed to evaluate the effects of dexmedetomidine on intraoperative blood loss, hemodynamic stability, and postoperative outcomes in trauma patients undergoing femoral intramedullary nailing surgery. Our results suggest that dexmedetomidine significantly reduced intraoperative blood loss and contributed to more stable hemodynamic parameters, including heart rate and systolic blood pressure, when compared to the control group [26-28]. Additionally, although the difference in blood transfusion rates was not statistically significant, the dexmedetomidine group required fewer transfusions. The recovery time was notably shorter in the dexmedetomidine group, further supporting its potential benefits in the management of trauma patients [29].

One of the primary outcomes of our study was the evaluation of intraoperative blood loss. The dexmedetomidine group experienced significantly lower blood loss during surgery compared to the control group. This finding is consistent with previous studies that have explored the hemostatic properties of dexmedetomidine, which may reduce intraoperative bleeding. Dexmedetomidine is

an alpha-2 adrenergic agonist that exerts its effects by binding to alpha-2 receptors in the central nervous system, leading to a decrease in sympathetic outflow. This results in vasoconstriction and a reduction in blood loss during surgical procedures, particularly in cases where significant bleeding is a concern, such as in trauma surgery. Several studies have indicated that dexmedetomidine can effectively reduce bleeding during both major and minor surgeries, making it a valuable adjunct in surgeries that require meticulous blood loss management [30-32].

In the context of femoral intramedullary nailing surgery, the reduced blood loss observed in our study related to the drug's ability to maintain a more controlled and stable surgical field. During trauma surgeries, patients are often at risk for significant blood loss due to the nature of the injuries. By stabilizing the hemodynamic status and reducing sympathetic activity, dexmedetomidine helps mitigate the blood pressure fluctuations that could otherwise lead to increased bleeding [33].

In addition to reducing blood loss, the use of dexmedetomidine in our study demonstrated an improved ability to stabilize hemodynamic parameters during surgery. Heart rate and systolic blood pressure were more stable in the dexmedetomidine group, suggesting that the drug's sympatholytic effects contribute to a more controlled perioperative course. This result is in line with previous literature that has shown dexmedetomidine's beneficial effects on hemodynamic stability during surgery [34].

Dexmedetomidine’s ability to lower heart rate and blood pressure is particularly important in trauma patients, who may already be experiencing stress and fluid shifts due to their injuries. Maintaining stable cardiovascular parameters in these patients is critical to preventing complications such as arrhythmias, myocardial ischemia, or exacerbation of preexisting conditions like hypertension. By reducing sympathetic tone and preventing the excessive release of catecholamines, dexmedetomidine not only aids in hemodynamic control but also contributes to a smoother anesthetic management during surgery [35].

Moreover, the beneficial effects of dexmedetomidine on hemodynamics attributed to its pharmacologic properties. As an alpha-2 adrenergic agonist, dexmedetomidine inhibits the release of norepinephrine, resulting in vasodilation and reduced sympathetic drive. This mechanism provides a unique advantage over other anesthetic agents that may not be as effective at controlling sympathetic outflow [36-38].

These hemodynamic benefits make dexmedetomidine an appealing option for trauma surgeries, where maintaining stable vital signs is often challenging due to the shock and trauma the patient is experiencing [39].

Although the difference in the need for blood transfusions between the two groups did not reach statistical significance ($p = 0.073$), there was a trend towards fewer transfusions required in the dexmedetomidine group. This finding is noteworthy, as reduced blood transfusion requirements are often an indication of effective intraoperative blood loss management. Previous studies have suggested that dexmedetomidine’s ability to reduce intraoperative bleeding can translate into fewer transfusion needs postoperatively, as less blood loss reduces the likelihood of needing blood products to compensate for intraoperative volume deficits [40-42].

While the reduction in transfusions was not statistically significant in this study, it is possible that with a larger sample size, the difference would have reached significance. This is an important consideration for future studies, as reducing the need for blood transfusions can have significant clinical implications, including fewer transfusion-

related complications, reduced healthcare costs, and improved patient outcomes [43-45]. In addition to transfusion requirements, the dexmedetomidine group also exhibited a shorter recovery time compared to the control group. This attributed to the sedative properties of dexmedetomidine, which facilitate a smoother and faster emergence from anesthesia. A faster recovery time is particularly beneficial in trauma patients, who often require intensive care following surgery. Shortening the recovery period can help minimize the duration of intensive monitoring and reduce the overall hospital stay, which in turn improves resource utilization and lowers healthcare costs [46].

Despite the promising findings of this study, several limitations noted. First, the sample size of 60 patients may not be large enough to detect small but clinically meaningful differences, particularly in secondary outcomes such as blood transfusion requirements. Future studies with larger sample sizes could provide more definitive conclusions regarding the effect of dexmedetomidine on blood transfusion rates and postoperative complications [47].

Additionally, while this study focused on trauma patients undergoing femoral intramedullary nailing surgery, the results may not be directly applicable to other types of surgery. Further studies should examine the effects of dexmedetomidine in different surgical settings, particularly in surgeries with varying levels of blood loss and hemodynamic instability. Investigating the drug's impact on different patient populations, such as those with preexisting cardiovascular disease or obesity, could also provide insights into its broader applicability [48].

Another limitation is the short-term follow-up period in this study. Long-term outcomes, such as the incidence of postoperative infections, complications, or the impact on functional recovery, evaluated. A more comprehensive follow-up assessment could provide valuable information on the overall benefits and risks of dexmedetomidine in trauma patients [49].

Conclusion

In conclusion, our study demonstrates that dexmedetomidine has a significant impact on reducing intraoperative blood loss and stabilizing hemodynamic parameters in trauma patients undergoing femoral intramedullary nailing surgery. The drug's ability to reduce blood loss and provide stable cardiovascular support makes it an effective adjunct in trauma surgery.

While the need for blood transfusions did not differ significantly between the two groups, the dexmedetomidine group showed a faster recovery time. These findings suggest that dexmedetomidine may offer significant advantages in improving surgical outcomes for trauma patients, particularly in the management of blood loss and postoperative recovery. Further studies with larger sample sizes and longer follow-up periods are necessary to confirm these results and explore the broader applications of dexmedetomidine in trauma surgery

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