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EFFECTS OF PRONE POSITION ON HEMODYNAMICS DURING LONG DURATION SPINE PROCEDURES

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ABSTRACT

Background: *The prone position is widely used for posterior spine procedures as it provides optimal surgical exposure. However, prolonged prone positioning can cause significant physiological alterations, particularly affecting cardiovascular stability during anesthesia. These changes become more pronounced during long duration surgeries and may increase intraoperative risks if not managed appropriately.*

Objective: *To evaluate the effects of prone positioning on hemodynamic parameters during long duration spine procedures and to assess intraoperative management strategies and perioperative outcomes.*

Methodology: *This prospective observational study was conducted on 79 patients undergoing elective spine surgery in the prone position with operative duration exceeding three hours. Hemodynamic parameters including mean arterial pressure (MAP), heart rate (HR), pulse pressure variation (PPV), and surgical pleth index (SPI) were recorded at predefined intraoperative intervals. Data regarding positioning time, type of positioning supports, fluid administration, vasopressor use, blood loss, transfusion requirements, and postoperative complications were collected and analyzed using descriptive statistics.*

Results: *Intraoperative hypotension was observed in 38% of patients, while bradycardia occurred in 13.9%. Vasopressor support was required in 26.6% of cases, and fluid boluses were administered in 54.4%. Blood transfusions were required in 53.2% of patients. The majority of patients (89.9%) experienced no immediate postoperative complications.*

Conclusion: *Prone positioning during long duration spine procedures is frequently associated with hemodynamic instability, particularly hypotension. With vigilant monitoring, appropriate positioning techniques, optimized fluid therapy, and timely vasopressor support, these changes can be effectively managed, making prone positioning a safe and practical approach for complex spine surgeries.*

Keywords: *Prone position, Spine surgery, Hemodynamic changes, Hypotension, Anesthesia*

INTRODUCTION

CHAPTER 1

The prone position is considered the ideal and most commonly used position for thoracic and lumbar spine surgeries, as it provides optimal surgical exposure, fluoroscopic access, and

allows safe spinal instrumentation. This positioning becomes especially important in complex and long-duration procedures such as multilevel decompressions, spinal fusions, osteotomies, and deformity corrections. As surgical duration increases, the physiological effects of prolonged prone positioning become more relevant to anesthetic management, tissue perfusion, and postoperative outcomes (1).

Hemodynamic alterations during prolonged prone positioning occur due to a combination of mechanical, ventilatory, and anesthetic factors. External abdominal compression and increased intra-abdominal pressure (IAP) can partially obstruct the inferior vena cava, leading to reduced venous return and decreased cardiac preload. In addition, positive pressure ventilation increases intrathoracic pressure, which further impairs venous return and alters right and left ventricular filling. These effects are compounded by anesthetic-induced vasodilation, progressive fluid shifts, hypothermia, and gradual changes in tissue compliance over the course of long surgeries (2,3).

Short periods of prone positioning may produce transient hemodynamic changes that are easily corrected with small fluid boluses or vasopressor support. However, in multi-hour spine procedures, these changes evolve gradually. Ventilator pressures and mechanical power tend to increase over time, particularly in patients with higher body mass index (BMI). At the same time, prolonged anesthesia blunts autonomic responses, while increasing abdominal wall tension and interstitial edema can further elevate IAP. These time-dependent changes are associated with late-onset hypotension, increased venous congestion, greater epidural venous bleeding, and higher transfusion requirements (2,4).

The transition from supine to prone position itself can significantly affect hemodynamics. Compression of the abdomen increases IAP and right atrial pressure, narrowing the venous return gradient and reducing cardiac output. Increased IAP also distends the epidural venous plexus, contributing to increased surgical bleeding. Positioning systems that allow the abdomen to hang freely, such as Jackson-type tables or wide chest supports, have been shown to improve venous return, maintain mean arterial pressure, and reduce blood loss compared to frames that cause ventral compression (4,5).

Ventilatory factors also play a critical role. Positive pressure ventilation reduces left ventricular afterload but increases right ventricular afterload, particularly when airway pressures rise during prolonged proning. Studies suggest that avoiding excessive peak and mean airway pressures, and using pressure-controlled ventilation when appropriate, may help reduce IAP and improve hemodynamic stability during spine surgery (6).

Patient-related factors further influence these changes. Obesity increases baseline IAP and ventilatory demands, placing additional strain on right ventricular function and venous return. Elderly patients often have reduced baroreflex sensitivity and may rely more on vasopressor support to maintain mean arterial pressure. Recent randomized trials have shown that continuation of angiotensin receptor blockers on the day of surgery increases intraoperative vasopressor requirements without providing hemodynamic benefit, supporting their preoperative withholding in prone spine procedures (3).

Despite advances in positioning, ventilation, and monitoring strategies, evidence focusing specifically on long-duration spine surgeries remains limited. Understanding these hemodynamic changes is essential for optimizing anesthetic management and improving outcomes in prolonged prone spine procedures.

CHAPTER 2
METHODOLOGY

This cross-sectional study was conducted at Sheikh Zaid Hospital, Mansoorah Hospital, and Jinnah Hospital. A purposive sampling technique was used to enroll 79 adult patients (ASA I-III) scheduled for elective posterior spine surgery requiring prone positioning for at least three hours. Patients with severe cardiovascular disease or those undergoing emergency surgery were excluded. The study documented patient demographics, the type of spine surgery performed (lumbar, thoracic, lumbosacral, or coccygeal), and details of general anesthesia, including induction and maintenance agents. The main objective was to

evaluate the effects of prone positioning on hemodynamics during long-duration spine procedures, with special attention to mean arterial pressure (MAP), heart rate (HR), surgical pleth index (SPI), and the requirement for vasopressors. Data were collected using a structured questionnaire, and continuous monitoring of cardiovascular parameters was performed throughout the procedure. Positioning time, type of support, fluid and blood management, and postoperative complications were also recorded and analyzed to understand the overall hemodynamic impact and clinical outcomes. Analysis was performed using SPSS version 27. Postoperative outcomes, including ICU admission and complications, were also noted for analysis.

CHAPTER 3
RESULTS

3.1: Age Group

	Total (n)	Minimum (years)	Maximum (years)
Age	79	21	76
Weight(kg)	79	45	98

This table presents descriptive statistics for 79 patients, showing age ranging from 21 to 76 years (mean 50.11) and weight from 45 to 98 kg (mean 72.58). The gender distribution included 44 females and 35 males, showing a slightly higher proportion of female patients.

3.2 Types of Spine Surgeries

Type of Spine Surgery	Frequency	Percent
lumber	23	29.1%
thoracic	32	40.5%
lumbosacral	20	25.3%
Coccygeal	4	5.1%
Total	79	100.0%

The types of spine surgeries were predominantly thoracic (40.5%), lumbar (29.1%), and lumbosacral (25.3%), while coccygeal procedures were less frequent (5.1%).

3.3: Positioning and Support

The time taken to position patients from supine to prone ranged from 2 to 20 minutes, with a mean of 10 ± 4.5 minutes. Chest rolls were the most commonly used support (50.6%), followed by Jackson frames (24.1%) and bolsters (22.8%).

Type of Support Used	Frequency	Percent
Bolsters	18	22.8%
Chest Rolls	40	50.6%
Jackson	19	24.1%
other	2	2.5%
Total	79	100.0%

3.4: Drugs Used

Drugs	Induction	Maintenance
Propofol	21	20
Midazolam	21	-
	7	-
Ketamine	18	17
Sevoflurane	-	20
other	12	22
Total	79	79

For induction, Propofol and Midazolam were each used in 26.6% of patients, followed by Ketamine (22.8%) and Atracurium (8.9%). For maintenance, Propofol and Sevoflurane were each used in 25.3% of patients, Atracurium in 21.5%, and other agents in 27.8%.

3.5: Monitor Readings and Vasopressors Use.

Descriptive Statistics

	Minimum	Maximum	Mean
SPI (Surgical Pleth Index)	21	60	40.0380
MAP (Mean Arterial Pressure)	63	100	79.5443
Heart rate (bpm)	52	100	77.3291
pulse pressure variations	5	20	12.0506

Use of Vasopressors

	Frequency	Percent
yes	21	26.6%
No	58	73.4%
Total	79	100%

This table presents descriptive statistics for 79 patients, showing SPI ranging from 21 to 60, MAP from 63 to 100 mmHg , heart rate from 52 to 100 bpm, and pulse pressure variations from 5 to 20.

Vasopressors were required in 21 patients (26.6%), while the majority (73.4%) did not require them.

Parameter	Minimum	Maximum
Total Crystalloids Given	650	3550
Total Colloids Given	0	1200
Blood Loss (mL)	132	1970

3.6: Fluid and Blood Management

Fluid bolus was administered to 43 patients (54.4%), while 36 patients (45.6%) did not receive a bolus. Total crystalloids ranged from 650 to 3550 mL (mean 1736.77 ± 650 mL), and total colloids ranged from 0 to 1200 mL (mean 585.89 ± 350 mL). Blood loss ranged from 132 to 1970 mL, with 42 patients (53.2%) receiving transfusions.

3.7: Hemodynamic Events

Fluid Bolus Given	Frequency	Percent
Fluid Bolus	43	54.4
No Fluid Bolus	36	45.6
Blood Transfusion	42	53.2
No Transfusion	37	46.8

Event	Frequency	Percent
Hypotension	30	38.0
Bradycardia	11	13.9
Monitoring Interruption	13	16.5
No Event	-	-

Hypotension (MAP <25% of baseline) occurred in 30 patients (38.0%). Bradycardia (HR <50 bpm) was observed in 11 patients (13.9%). Monitoring interruptions occurred in 13 patients (16.5%).

3.8: Postoperative Complications

Complication	Frequency	Percent
ICU Admission	16	20.3
Nerve Injury	5	6.3
Vision Loss	1	1.3
Delayed Recovery	2	2.5
No Complication	71	89.9

Postoperative ICU admission was required in 16 patients (20.3%). Immediate complications were rare: nerve injury occurred in 5 patients (6.3%), vision loss in 1 patient (1.3%), and delayed recovery in 2 patients (2.5%), while 71 patients (89.9%) had no complications.

In summary, prone positioning during long-duration spine surgery was associated with measurable hemodynamic changes, including hypotension in 38% and bradycardia in 13.9% of patients, with 26.6% requiring vasopressors. Positioning time and type of support influenced stability, and fluid/blood management was critical to maintaining adequate perfusion. Despite these intraoperative fluctuations, immediate postoperative complications were

minimal. Overall, the findings indicate that prone positioning induces clinically significant but manageable hemodynamic alterations, and careful monitoring, timely interventions, and supportive measures can effectively maintain cardiovascular stability throughout the procedure.

CHAPTER 4
DISCUSSION

This research assessed 79 patients undergoing long-term spinne surgeries in the prone position and pointed out significant hemodynamics, perioperative management techniques, and the general outcome of the surgery. The findings showed that hypotension (38%), and bradycardia (13.9) were the most common hemodynamic changes.

These observations are consistent with the established physiological effects of prone positioning, where mechanical compression of the abdomen and thorax reduces venous return, leading to decreased preload, lower cardiac output, and altered stroke volume.(7)

Similar hemodynamic disturbances during prone spine surgery have been reported in earlier studies, confirming that maintaining cardiovascular stability remains a consistent challenge for anesthesia teams.(8)

The relatively high incidence of hypotension in the present study is comparable to previous reports and is mainly attributed to impaired venous circulation after proning, secondary to increased intra-abdominal and intrathoracic pressures. Bradycardia, although less common, may occur due to reflex parasympathetic activation in response to reduced cardiac filling. These observations emphasize the importance of anticipating such changes and intervening early to prevent sustained intraoperative instability.(9)

Positioning support was an important factor in this cohort. Chest rolls were used in more than half of the patients, while bolsters were used in nearly one-quarter. Prior echocardiographic studies have demonstrated that appropriate positioning systems help preserve preload and cardiac output when compared with more rigid frames. The frequent use of these supports in our study may explain the absence of severe or refractory hemodynamic compromise despite prolonged surgical duration.(10)

Hemodynamic disturbances were primarily managed with fluid boluses and vasopressors, required in 54.4% and 26.6% of patients, respectively. This approach aligns with contemporary goal-directed hemodynamic management strategies, which aim to correct hypotension while avoiding excessive fluid administration.(11)

Recent randomized studies have also shown that individualized fluid loading around the time of proning improves cardiovascular stability during spine surgery, further supporting the management practices used in this study.(12)

Postoperative outcomes were largely favorable, with nearly 90% of patients experiencing no major complications. The low incidence of nerve injury (6.3%) and vision loss (1.3%) is consistent with previously published data, where complications are uncommon when careful positioning, padding, and continuous monitoring are maintained.(13)

These findings reinforce that prone positioning is generally safe when standard safety measures are strictly followed.

An additional observation in this study was the assessment of positioning time, which ranged from 2 to 20 minutes. Although often underreported, prolonged positioning may contribute to early hemodynamic instability and procedural delays. Efficient and well-coordinated positioning can reduce physiological stress and improve overall perioperative workflow, highlighting the importance of teamwork between surgical and anesthesia staff.

Overall, this study supports existing evidence that prone positioning has a significant impact on cardiovascular physiology during long-duration spine surgery. However, with proper positioning aids, careful fluid management, selective vasopressor use, and vigilant monitoring, these effects can be effectively controlled. Prone positioning remains a safe and essential technique for complex spinal procedures when performed with adequate preparation and attention to hemodynamic stability.

CHAPTER 5
CONCLUSION

5.1: CONCLUSION

Prone positioning during long duration spine procedures frequently results in hypotension and bradycardia, though these can be effectively managed with fluids, vasopressors, and appropriate support systems. Complication rates were low, and positioning time may play a role in intraoperative stability. Further multicenter studies with advanced hemodynamic monitoring and direct comparison of support devices are recommended.

5.2: RECOMMENDATIONS

- Pre-op cardiovascular optimization & medication plan
- Implement goal-directed fluid therapy (GDFT) with an explicit vasopressor algorithm
- Advanced/increased hemodynamic monitoring for high-risk cases

5.3: LIMITATIONS

- Direct cardiac index or stroke volume measurements were not performed.
- Outcomes were not compared across different support systems.
- Long-term postoperative outcomes were not assessed.

CHAPTER 8

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