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A Comparative Evaluation of the Effect of Prone Positioning Methods on Blood Loss and Intra-Abdominal Pressure in Obese Patients Undergoing Spinal Surgery

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Abstract:

Background Improper prone positioning of obese patients for spine surgery can increase the intra-abdominal pressure (IAP), resulting in increased bleeding from epidural venous plexus. The choice of prone positioning frame can be an important determinant of the IAP.

Materials and Methods This prospective, randomized study was performed on obese patients (body mass index ≥ 30) scheduled for lumbar laminectomy. After administration of general anesthesia, patients were positioned prone either on Wilson's frame (group W), or on horizontal bolsters (group H). IAP was recorded at three intervals: (1) in supine position, (2) 10 minutes after prone positioning, and (3) in prone position at the end of surgery. Intraoperative blood loss was measured quantitatively and assessed subjectively by the surgeon.

Results A total of 60 patients were enrolled with 30 patients in each group. IAP in supine position was similar in both groups. However, IAP 10 minutes after prone positioning was significantly higher at 11.44 ± 1.61 mm Hg in group W as compared to 9.56 ± 1.92 mm Hg in group H (p = 0.001). Similarly, IAP of 12.24 ± 1.45 mm Hg in group W, measured on completion of surgery was significantly higher than 9.96 ± 2.35 mm Hg in group H (p = 0.001). Mean total blood loss of 440.40 ± 176.98 mL in group W was significantly higher than 317.20 ± 91.04 mL in group H (p = 0.003).

Conclusion Obese patients positioned prone on Wilson's frame had significantly higher IAP and blood loss compared to patients positioned on horizontal bolsters.

Keywords
► prone position
► spinal fusion
► spine surgery
► intra-abdominal pressure
► Wilson's frame

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Introduction

The choice of prone positioning system for obese patients is often at the discretion of operating surgeon. Various positioning frames like Wilson's frame, Relton–Hall frame, Andrews frame, Jackson table, etc. have been employed for this purpose.[1] Wilson's frame is one of the most commonly employed systems for this purpose. This is an expandable radiolucent frame with a padded vertical bar on each side (►**Fig. 1**). The pads can be adjusted laterally as per the built of the patient and flexion can be achieved as per the desired lordosis.[2] Another method of prone positioning at our institution is over the horizontal bolsters (►**Fig. 2**). Horizontal bolsters are actually an adaptation from Relton–Hall frame[3] and consist of two bolsters, one of which is kept under the patient's upper part of the chest and the other under the iliac crests of the patient.

Despite best efforts, placing obese patients in prone position is a challenge because the pendulous abdomen often hangs between the supporting pads and may touch the operating table. The pressure on abdomen can contribute toward increasing the intra-abdominal pressure (IAP).[4] In addition, obese patients tend to have higher baseline IAP as compared to patients with normal body mass index (BMI).[5] Thus, any further increase in IAP due to improper positioning can be detrimental. This makes the choice of prone positioning frames extremely crucial.

Most of the studies conducted to evaluate the effect of prone positioning systems on IAP have been conducted on patients with normal BMI.[4,6,7] The results of such studies, however, may not be valid for obese patients. The only study to evaluate the effect of BMI on IAP was conducted by Han et al, who reported that IAP increases to a greater extent when patients with increased BMI are positioned prone.[4] However, all the patients enrolled in their study had BMI of less than 30 Kg/m^2 and were either of normal weight or in overweight category. The present study was, therefore, designed to evaluate the effect of prone positioning frames used at our hospital (Wilson's frame vs. horizontal bolsters) on IAP and blood loss in obese patients undergoing lumbar spine surgery.

Fig. 1 Patient lying in prone position over Wilson's frame.

Fig. 2 Patient lying in prone position over horizontal bolsters.

Materials and Methods

This prospective randomized, single-blinded study was conducted on obese patients having BMI ≥ 30 kg/m^2 scheduled for elective one or two level lumbar laminectomy and fusion at L4-5 and L5-S1 as a treatment for degenerative lumbar spine from October 15, 2013 to October 15, 2016 after obtaining informed consent from each patient. Patients belonging to the American Society of Anesthesiologists (ASA) classification class I or II were enrolled in the study after permission from the institutional ethics committee obtained vide DMCH/DTEC/2013/454. Study was also registered with the Clinical Trial Registry - India with registration number CTRI/2014/08/004903. Patients suffering from hypertension, cardiac, respiratory, liver, or renal disorders or those taking antiplatelets/anticoagulants were also excluded from the study. Pregnant patients or those having undergone previous spinal or abdominal surgery or contraindications or difficulty to the placement of transurethral bladder catheter were also not included in the study. Complete blood count, renal function tests, random blood glucose levels, prothrombin time (PT), activated partial thromboplastin time (PTT), electrocardiogram (ECG), and chest X-ray were performed for all patients.

All patients were premedicated with oral lorazepam 2 mg and ranitidine 150 mg, at bed time on the night prior to surgery. In the operating room intravenous access was secured. Standard monitoring in the form of ECG, heart rate (HR), SpO_2, noninvasive blood pressure, and end-tidal carbon dioxide ($ETCO_2$) was carried out. These parameters were monitored throughout the procedure and recorded at an interval of 5 minutes. General anesthesia was induced with midazolam 1 mg, glycopyrrolate 0.2 mg, fentanyl 2 µg/kg, and propofol 2 mg/kg. Atracurium 0.5 mg/kg was used to facilitate orotracheal intubation. Anesthesia was maintained with 60% N_2O in O_2, isoflurane, and fentanyl 0.5 to 1 mcg/kg as required. The muscular relaxation was maintained with atracurium 5 mg bolus every 15 to 20 minutes as guided by neuromuscular monitoring maintaining a train of four (TOF) count of 0. Ventilation was adjusted to maintain $ETCO_2$ between 30 and 35 mm Hg. A 16-Fr Foley's transurethral bladder catheter was placed in all patients after administration of general anesthesia.

Patients were randomly allocated into two groups using computer-generated random numbers which were kept in sealed envelopes. The envelopes were opened by an anesthesiologist not involved in the study or care of the patient and this would dictate the prone positioning frame for the particular patient. Group W (*n* = 50%) patients were placed prone on a Wilson's frame, whereas those allotted to group H (*n* = 50%) were positioned prone on horizontal bolsters (►**Fig. 3**). The patients were placed in prone position adjusting the pad width of Wilson's frame or horizontal bolsters, as deemed appropriate for optimal positioning. The abdomen was allowed to hang freely as much as possible, to avoid abdominal wall tension. Female breasts were positioned to avoid any undue pressure. Head of the patient was supported on soft foam padded head rest in and side supports were applied in all cases to stabilize the patient. After positioning, eyes and pressure points were also checked to ensure that there was no undue pressure on these. Blood pressure and HR were maintained around 15% of baseline by adjusting depth of anesthesia by the anesthesiologist managing the case.

IAP was measured in the following positions and time intervals after ensuring TOF count of 0 in all patients:

IAP 1 - supine after the induction after placement of Foley's catheter;

IAP 2 - ten minutes after correct positioning of the patient in prone position; and

IAP 3 - at the end of surgery, before turning the patients supine.

After recording IAP, isoflurane was stopped and patients were put into supine position. Fresh gas flow was changed to 4 L/min of oxygen, residual neuromuscular block was reversed with neostigmine 2.5 mg intravenously and glycopyrrolate 0.4 mg intravenously, and tracheal extubation was performed. Any adverse events during the recovery period were noted.

Intra-Abdominal Pressure Measurement

The technique used to measure IAP was based on the procedure described by Kron et al.[8] The basis of this technique is that the IAP can be indirectly determined through the measurement of transurethral bladder pressure, since the wall of urinary bladder behaves as a passive diaphragm when the bladder volume is between 50 and 100 mL in an adult patient.[9]

The sterile tubing of the urinary drainage bag was connected to the indwelling Foley's catheter. The Foley's catheter was cross-clamped at the connection point with the tubing of urinary bag. An 18-gauge needle was then inserted through the catheter sampling port and connected to a pressure transducer. Each measurement was performed by injecting 50 mL 0.9% sterile saline in the empty bladder through the indwelling Foley catheter taking mid-axillary line as the reference point for each measurement[10] (►**Fig. 4**). The bladder was continuously emptied between measurements. The mean abdominal pressure was recorded at the end of expiration to eliminate the influence of respiratory cycle on IAP.[6]

Assessment of Blood Loss

Blood loss was measured by noting the difference in weights of gauze pieces and surgical sponges before the start and at the end of surgery. Also, the contents from suction bottle were noted and intraoperative saline used for irrigation was subtracted from this. Blood loss was obtained by summation of these two.

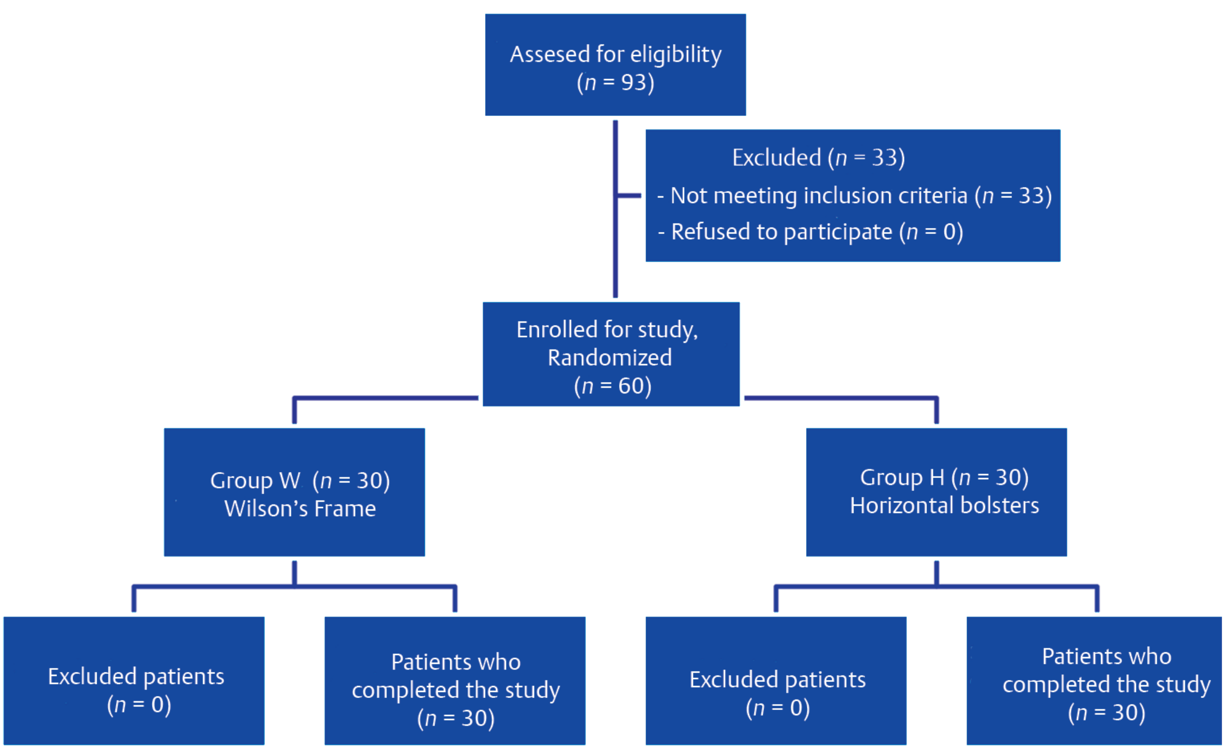

Fig. 3 Consort diagram.

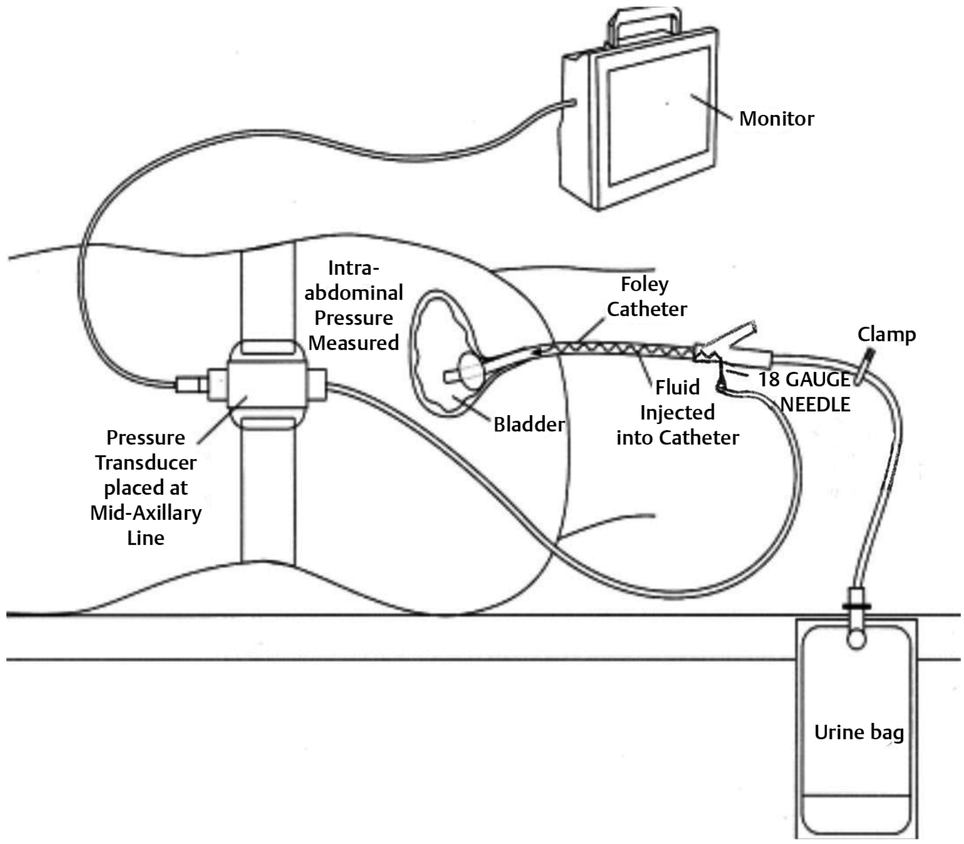

Fig. 4 Schematic illustration of a patient in supine position with the monitoring system of the bladder pressure.

Subjective assessment of blood loss was performed by the operating neurosurgeon. The degree of bleeding was described by the level of impairment of the visual field with blood[11]:

0–no impairment;
1–slightly impaired;
2–impaired; and
3–heavily impaired.

To minimize the variability of such an evaluation, all cases enrolled for the study were operated upon by a single neurosurgeon (blinded to the recordings of IAP). In addition, hemoglobin (Hb) was measured 24 hours postoperatively and fall in Hb from the preoperative level was calculated to indirectly estimate intraoperative blood loss.

Statistical Analysis

A post hoc power analysis was conducted using the software package, G*Power version 3.1.9.2 (Franz Faul, University Kiel, Germany). The alpha level used for this analysis was $p < 0.05$ and beta was 0.20. Sample size was estimated from the results of previous study[7] using the IAP in prone position as the parameter, which is the primary outcome of our study. A sample size of 25 subjects per group provided power of 0.92 and with an effect size of 0.97 with 10% chance of error ($\alpha = 0.05$, $\beta = 0.20$, and confidence interval of 95%). Data were reported in terms of mean value with variability expressed as standard deviation and frequencies (number of cases). Comparison of quantitative variables between the study groups were done using Student's *t*-test and Mann–Whitney *U* test for independent samples for parametric and nonparametric data, respectively. For comparing our primary objective, multiple comparisons at different time points were done using repeated analysis of variance. For comparing categorical data, chi-square test was performed and exact test was used when the expected frequency was less than 5. A probability value (*p*-value) less than 0.05 was considered statistically significant. All statistical calculations were done using SPSS (Statistical Package for the Social Science) SPSS 21 version statistical program for Microsoft Windows.

Results

Sixty patients were enrolled during the study period with 30 patients in each group. None of the patients were excluded (►**Fig. 3**). Both groups were comparable with regards to demographic profile like mean age, weight, height, BMI, sex distribution, and ASA classification (►**Table 1**). The preoperative coagulation profile measured in terms of mean PT, PTT, international normalized ratio, and platelet counts were statistically similar in both the groups (►**Table 2**). The difference in mean duration of anesthesia and mean duration of surgery was also statistically not significant (►**Table 2**). Comparable decrease in mean arterial pressure (MAP) and a

Table 1 Demographic profile

	Group W (*n* = 30)	Group H (*n* = 30)		Difference		95% CI of the difference	
	Mean ± SD	Mean ± SD	*p*-Value	Mean	Standard error	Lower	Upper
Mean age (y)	48.64 ± 8.96	48.20 ± 8.25	0.922	0.24	2.44	−4.657	5.137
Sex M:F ratio	14:16	14:16	1.000				
Mean body weight (kg)	92.49 ± 11.10	93.19 ± 11.26	0.826	−0.70	3.16	−7.058	5.658
Mean height (cm)	163.24 ± 6.57	162.88 ± 6.83	0.850	0.36	1.89	−3.449	4.169
BMI (kg/m^2)	34.61 ± 2.49	35.03 ± 2.55	0.556	−0.42	0.71	−1.856	1.011
ASA I:II	17:13	17:13	1.000				

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index.

Table 2 Mean duration of surgery and coagulation profile

	Group W0 (*n* = 30)	Group H (*n* = 30)		Difference		95% CI of the Difference	
	Mean ± SD	Mean ± SD	*p*-Value	Mean	Standard error	Lower	Upper
Mean anesthesia duration (min)	201.68 ± 54.48	199.84 ± 47.49	0.899	3.76	14.22	−27.221	30.901
Mean surgery duration (min)	152.00 ± 45.71	151.68 ± 39.74	0.916	4.56	11.68	−23.078	25.638
Mean PT (s)	12.19 ± 1.56	11.85 ± 1.01	0.366	0.72	0.35	0.018	1.422
Mean PTT (s)	40.12 ± 4.17	41.24 ± 2.20	0.241	−1.12	0.94	−3.015	0.775
Mean INR	1.08 ± 0.13	1.02 ± 0.06	0.066	0.06	0.03	0.002	0.128

Abbreviations: INR, international normalized ratio; PT, prothrombin time; PTT, partial thromboplastin time.

compensatory increase in HR within 10 to 20% of the baseline were observed after positioning the patients prone in both the groups. However, mean MAP and HR were statistically similar in both the groups at all time intervals. No adverse events were noted during the recovery period.

The mean baseline IAP in supine position was statistically similar in both the groups ($p = 0.540$). IAP in both groups increased after placing patients in prone position, but the IAP in group W was significantly higher at 11.44 ± 1.61 mm Hg as compared to 9.56 ± 1.92 mm Hg in group H ($p = 0.001$). Similarly, IAP of 12.24 ± 1.45 mm Hg in group W, at the end of surgery, was significantly higher than 9.96 ± 2.35 mm Hg in group H ($p = 0.001$) (►**Table 3**).

Mean total blood loss of 440.40 ± 176.98 mL in group W was significantly higher than 317.20 ± 91.04 mL in group H ($p = 0.003$). Similarly, mean postoperative fall in Hb of 1.56 ± 0.77 g/dL was significantly greater in group W as compared to 1.02 ± 0.34 g/dL in group H ($p = 0.002$) (►**Table 4**). In group H, 23 patients had grades 0 or 1 bleeding as compared to 15 patients in group W. None of the patients in group H had grade 3 bleeding as compared to 5 patients in group W (►**Fig. 5**). Thus, surgeon reported clearer surgical field in group H more often as compared to group W (►**Fig. 5**).

Discussion

This is the first study undertaken to compare the two commonly used prone positioning systems in obese patients. Only patients having BMI ≥ 30 were enrolled as this particular BMI has been widely accepted as cut-off to define obesity.[12] The method chosen to measure IAP has been devised by Kron et al and later standardized and validated by Fusco et al.[8,13] This method is noninvasive, accurate, and the most commonly method used for measuring IAP.[7]

The mean baseline IAP recorded in the present study in supine position was within the normal range of 4 to 8 mm Hg described by Sanchez et al[14] but slightly higher than that reported by Park and Malhotra et al.[2,7] This could be due to the fact that both these studies were conducted on patients with normal BMI, whereas the present study enrolled only obese patients. Obese patients tend to have higher baseline IAP and the direct correlation between IAP and BMI has been previously reported by Wilson et al.[15]

The increase in mean IAP in both groups on placing the patients in prone position is on the expected lines as IAP tends to increase on placing the patients prone.[13] This increase in IAP happens to an even greater extent in patients with higher

Table 3 Mean intra-abdominal pressure among the two groups (mm Hg)

	Group W (*n* = 30)		Group H (*n* = 30)			Difference		95% CI of the difference	
	Mean	SD	Mean	SD	*p*-Value	Mean	Standard error	Lower	Upper
Mean IAP 1	5.64	1.11	5.84	1.18	0.54	−0.16	0.34	−0.852	0.452
Mean IAP 2	11.44	1.61	9.56	1.92	0.001	2.56	0.49	0.874	2.886
Mean IAP 3	12.24	1.45	9.96	2.35	0.001	2.36	0.46	1.168	3.392

Table 4 Intraoperative blood loss

	Group W (*n* = 30)	Group H (*n* = 30)		Difference		95% CI of the difference	
	Mean ± SD	Mean ± SD	*p*-Value	Mean	Standard error	Lower	Upper
Intraop blood loss (mL)	440.40 ± 176.98	317.20 ± 91.04	0.003	123.20	39.80	43.169	203.231
Wet-dry gauzes (g)	160.00 ± 73.20	120.00 ± 64.29	0.046	40.00	19.49	0.823	79.177
Blood in suction bottles (mL)	280.40 ± 105.45	197.20 ± 56.09	0.001	83.20	23.89	35.169	131.231
Preop Hb - postop Hb (g/dL)	1.56 ± 0.77	1.02 ± 0.34	0.002	0.54	0.17	0.201	0.879

Abbreviations: Hb, hemoglobin; SD, standard deviation.

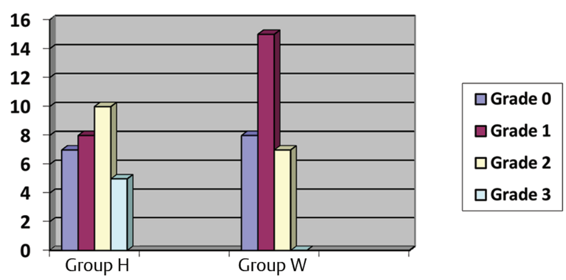

Fig. 5 Subjective assessment of grades of bleeding by surgeon.

BMI.[15] However, the IAP in group W was significantly higher than group H at both intervals in prone position. This finding has great clinical implications for both surgeon and the anesthesiologist. The reason for higher IAP in group W in prone position could be that pendulous abdomen of obese patients does not fit well between the two vertical bars of Wilson's frame and is compressed excessively despite attempts to optimize the width between the pads of Wilson's frame.[4] Park, in a study on Wilson's frame had also noted that too narrow pads result in increase in IAP.[2] The other reason or contributing factor could be that the two padded bars of Wilson's frame exert pressure on the chest and abdominal wall.[16] Malhotra et al had also reported that Wilson's frame is associated with greater IAP as compared to spinal table and thermo-regulated pads, which were the other alternative frames available in their set up.[7]

The HR and MAP were statistically similar in both groups at all time intervals. This finding is important because prone position often results in reduction of stroke volume and cardiac index thus predisposing patients to hypotension.[1] Improper placement of patients in prone position can worsen these hemodynamic derangements by causing inferior vena cava (IVC) compression resulting in reduced venous return.[17] Second, similar hemodynamic profile in both groups allows comparison of blood loss among the two groups.

We observed significantly greater bleeding in group W, despite similar coagulation profile and MAP as compared to group H. This increased bleeding could be due to higher IAP in group W resulting in engorgement of epidural veins.[18,19] The epidural venous plexus, described by Batson, is a valveless communication between the vertebral veins and IVC which can get congested if IVC pressure increases.[20] Han et al also noted a direct relationship between IAP and intraoperative blood loss, and based on their findings, they anticipated substantially higher blood loss in morbidly obese patients.[4] We assessed bleeding both by subjective and objective means. Subjective assessment was performed by the operating surgeon by visually inspecting the surgical field for obscuration with blood. This flooding of surgical field with blood has significant implications, as not only it increases the operating time but also the morbidity for the patient.[21] Though this method has its limitations but to reduce the observer bias, the surgeon was blinded to the results of IAP measurement. Greater blood loss in group W was also reflected in significantly greater fall in mean Hb as compared to group H. This increased blood loss did not warrant any need for any blood transfusion, though.

Certain limitations of our study are worth mentioning. First, the surgeon could not be blinded to the type of frame used and this does have a potential to introduce bias. Second, we could evaluate only two framing systems as these are the ones available at our institution. More such studies need to be undertaken so as to decide the best prone positioning system for obese patients.

Conclusion

Use of horizontal bolsters for prone positioning in obese patients result in lower IAP and intraoperative bleeding in comparison to Wilson's frame.

Conflict of Interest
None declared.

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