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A COMPARISON OF PHYSIOLOGICAL CHANGES INDUCED BY PRONE POSITION OVER WILSON'S FRAME AND HORIZONTAL BOLSTERS IN LUMBAR SPINE SURGERY – A RANDOMIZED PROSPECTIVE STUDY

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ABSTRACT

BACKGROUND: Ideal patient positioning involves balancing surgical comfort, against the risks related to the patient position. There is paucity of information on effect of prone position on blood loss and intra- abdominal pressure (IAP) and how these changes correlate with respiratory airway pressures. The study was designed to compare Wilson's frame and horizontal bolsters to find a better technique for better intraoperative optimisation of the patient.

METHODS: The study was conducted on 60 patients after obtaining approval from ethical committee. Patients were positioned prone on Wilson's frame (W) and Horizontal bolster (H). IAP was measured in the following positions and time intervals: IAP 1 (T1) - supine after the induction after placement of Foley's catheter; IAP 2 (T2) - 10 minutes after correct positioning of the patient in prone position; and IAP 3 (T3) - at the end of surgery, before turning the patient supine. Simultaneously, airway pressures and vitals were recorded. Blood loss was estimated at the end of surgery.

RESULTS: Mean IAP was significantly higher in group W at T2 and T3 ($p < 0.001$ each). Significantly higher airway pressuresobserved in Group W as compared to group H at T2 and T3. Blood loss in group W was significantly higher than average blood loss in group H ($p = 0.006$).

CONCLUSIONS: The patients who were positioned prone on horizontal bolsters for lumbar surgery had significantly lower IAP, airway pressures and lesser intraoperative blood loss as compared to patients positioned on Wilson's frame.

KEYWORDS: Spine surgery, prone position, intra-abdominal pressure**,**Wilson's frame, mean airway pressure, blood loss

INTRODUCTION

Position of the patient during surgery is at surgeon's disposition. Prone position is required for access to posterior anatomic structures including posterior head, neck, and spine during spinal surgery[1].Lumbar spine surgeries are performed to relieve compression on spinal cord, the so-called reason of "back pain" and are usually conducted in prone or ventral decubitus position which allows better access of the surgical view. Ideal patient positioning involves balancing surgical comfort, against the risks related to the patient position[1]. While in 1930's and 1940's the pioneers of spinal surgery faced difficulty due to abdominal compression, modern versions provided a solution. Various frames like Wilson's frame, Relton–Hall frame, Andrew's frame, Jackson table are commonly used for positioning of patient[2]. Wilson's frame is more commonly used at our institution for positioning. Another method used at our institution is horizontal bolsters (which is a modification of Relton hall frame) consisting of two pads kept under chest and iliac crest each.

Despite best efforts, maintaining prone position can be a physiological struggle. Turning the patient prone from the supine position is a blind period for anaesthesiologist[3]. Improper positioning may lead to complications like[4]

1. Post operative vision loss
2. Pressure ulcers on abdomen and thorax due inadequate padding
3. Injury to brachial plexus due to hyper abduction of arm leading commonly to ulnar nerve injury.
4. Cervical spine injury due to improper neck extension/ flexion/rotation
5. Hypotension
6. Raised intra-abdominal pressure

Direct pressure on orbits can cause trauma resulting in conjunctival edema,haemorrhage, chemosis, pain, and vision loss[4]. Compression of the abdomen restricts blood flow through the inferior vena cava, resulting in engorgement of the paravertebral and epidural veins[3]. This can increase bleeding in the surgical field. Hypovolemia in the prone patient can exacerbate hypoperfusion and may increase the likelihood of acute kidney injury, especially during procedures with high blood loss. Prone position also alters respiratory mechanics by decreasing respiratory compliance. Hence higher airway pressures may be required for adequate ventilation of the patient. This may further reduce cardiac output, increasing systemic venous pressure which is reflected on epidural venous plexus leading to oozing from surgical site. Venous pooling also puts the patient at increased risk of deep venous thrombosis (DVT). Above mentioned changes make the choice of prone positioning frames extremely crucial.

There is paucity of information on how prone position affects blood loss and intra-abdominal pressure and how these changes correlate with respiratory airway pressures. In view of large number of lumbar spine surgeries conducted in our hospital, the study was designed to compare Wilson's frame and horizontal bolsters to find a better technique for better intraoperative optimisation of the patient.

MATERIALS AND METHODS

This study was conducted after approval from ethical committee on non-obese patients having BMI < 30 kg/m2 scheduled for elective lumbar spine surgeries from **30 April, 2021 to 30 April, 2022.**This clinical research was done in accordance of the Ethical Principles for Medical Research Involving Human Subjects, outlined in the Helsinki Declaration of 1975 (revised 2013).Informed consent from each patient was obtained. Patients belonging to the American Society of Anaesthesiologists (ASA) classification class I or II were enrolled in the study. Hypertensive, diabetic and those with cardiac, respiratory, renal or hepatic disorders were excluded.

Each patient underwent a detailed pre-anaesthetic check-up and complete work up including, Complete blood count, renal function tests, random blood glucose levels, prothrombin time (PT), International Normalized Ratio (INR), Liver function tests, Bleeding time, Clotting time, electrocardiogram (ECG), and chest X-ray were performed for all patients.

After shifting patients to operating room, intravenous access was secured. Standard monitoring in the form of ECG, heart rate (HR), SpO2, non-invasive blood pressure, and end-tidal carbon dioxide (ETCO2) was carried out. These parameters were monitored throughout the procedure and recorded at an interval of 5 minutes. General anaesthesia was induced with injection midazolam 1 mg, glycopyrrolate 0.2 mg, fentanyl l-2 mcg/kg, and propofol 2 mg/kg. Injection Vecuronium0.1 mg/kg was used to facilitate endotracheal intubation. Maintenance was achieved with 60% N_2O in O_2 with isoflurane, injections fentanyl 0.5 to 1 mcg/kg top-ups as required and vecuronium0.1 mg/mg bolus every 15 to 20 minutes. Ventilation was adjusted to maintain $ETCO_2$ between 30and 35 mm Hg.

A 16-Fr Foley's transurethral bladder catheter was placed in all patients after administration of general anaesthesia.

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 = 30) patients were placed prone on a Wilson's frame (Fig 1), whereas those allotted to group H (n = 30) were positioned prone on horizontal bolsters (Fig 2). 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 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 anaesthesia by the anaesthesiologist managing the case. IAP was measured in the following positions and time intervals: IAP 1 –in supine position, after induction and placement of Foley's catheter**(T1)**; IAP 2 - ten minutes after proper positioning of the patient in prone position**(T2)**; and IAP 3 - at the end of surgery, before turning the patient supine**(T3)**. At the end of surgery patients were turned supine before reversing neuromuscular block with neostigmine

0.0.5 mg/kg intravenously and glycopyrrolate 0.008 mg/kg intravenously, and extubation was carried only after complete reversal of neuromuscular blockade. Any adverse events if present, were noted perioperatively. Intra operative blood loss was estimated by measuring blood contents in the suction bottle and weighing blood-soaked gauzes. Blood loss in the suction bottle wasestimated by subtracting irrigating saline volume from the volume of contents in the suction bottle. Blood loss in gauzes and pads was measured by subtracting the weights of dry gauzes from the total weight of blood-soaked gauzes. Estimated blood loss (mL) = (volume in suction bottle-irrigating saline volume) (mL)+[weight of blood-soaked gauzes (g)-dry gauze weight (g)]. Blood on drapes in the surgical field was neglected[2].

Fig. 1: Patient positioned prone on Wilson's frame Fig. 2: Patient positioned prone on horizontal bolsters

IAP MEASUREMENT

The technique used to measure IAP was based on the procedure described by Kron et al[5].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. The sterile tubing of the urinary drainage bag was connected to the indwelling Foley's catheter. A cross-clamp was applied slightly distalto the connection point of foley's catheter with the tubing of urinary bag. An 18-gauge needle was then inserted through the catheter sampling port and connected to a pressure transducer (Fig 3). Zeroing of the pressure transducer was done at the mid axillary level. Each measurement was performed by injecting 80 mL 0.9% sterile saline in the empty bladder through the indwelling Foley catheter. 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.

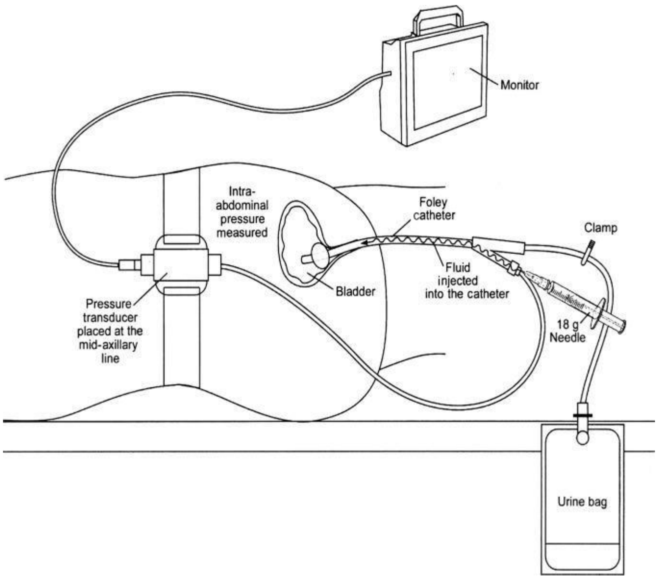

Fig. 3: Schematic representation of intra-abdominal pressure monitoring with patient in supine position.

STATISTICAL ANALYSIS

Sample size was estimated from results of previous study conducted by Sandeep Kundra et al. who studiedchanges in IAP and airway pressures in prone position while comparing between Horizontal Bolsters and Wilson's frame[2]. All the data was recorded in excel sheet and tabulated in terms of mean and standard deviation. Student's t-test was used to compare each variable at specified time points. P-value <0.05 was considered statistically significant.

RESULTS

A total of 60 patients were enrolled in the study with 30 patients randomly assigned to group W and H. Groups were compared with regards to BMI, haemodynamics, intra-abdominal pressure, airway pressures and blood loss.
Demographical data was comparable in both groups in terms of height (m), weight (Kg), and BMI (kg/m^2). 30 patients, 15 male and 15 female each were enrolled in group H and W. (Table 1)

	Group W (n = 30)		Group H (n = 30)		P - value
	Mean	SD	Mean	SD	
Height	1.57	0.1	1.55	0.1	0.62
Weight	63.83	8.96	62.63	12.11	0.76
BMI	25.9	2.37	25.78	3.04	0.4
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Table 1: Demographical Data.

Values are Mean ± SD. Group W- Wilson's frame group, Group H- Horizontal bolster group. Statistically significant difference (P < 0.05).

Heart rate at T1 was comparable in patients of both the groups. Increase in heart rate was observed at T2 and T3 in patients of both the group. Heart rate was significantly increased at T3 in group W (93.70 ± 7.35) as compared to group H (85 ± 13.01 ; p = 0.003). Heart rate was also seen to be higher in group W (92.51 ± 8.96) as compared to group H ((83.97 ± 12.24; p = 0.03) at T2.(Fig. 4)

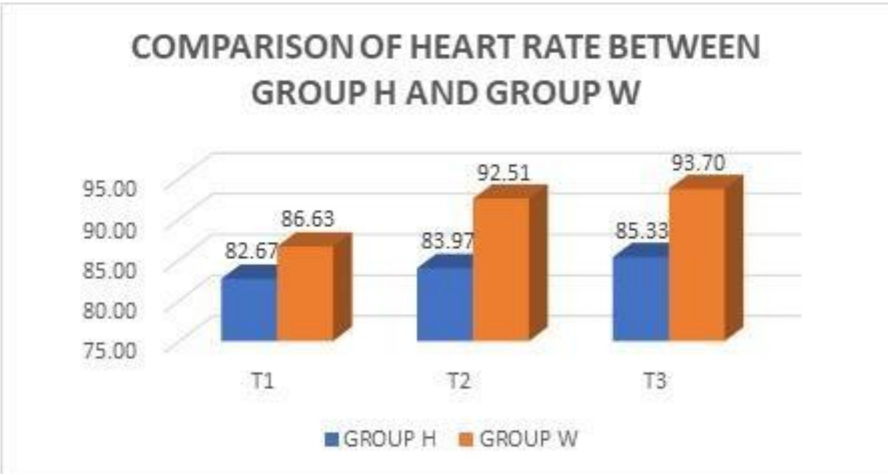

Fig. 4: Comparison of Average heart rate between patients of Group W and Group H at T1 (supine), T2 (10 min after prone position) and T3 (at the end of surgery before turning patient supine).

Average MAP at T1 in both groups was comparable and statistically insignificant. Average MAP at T2 in group W (84 ± 10.07mmHg) was less than that of group H (89 ± 8.82mmHg), difference being statistically significant (p = 0.03). However, average MAP at T3 in group W (94 ± 12.24 mmHg) was only marginally higher than that of group H (93 ± 10.24 mmHg), difference being statistically insignificant (p>0.05). (Fig. 5)

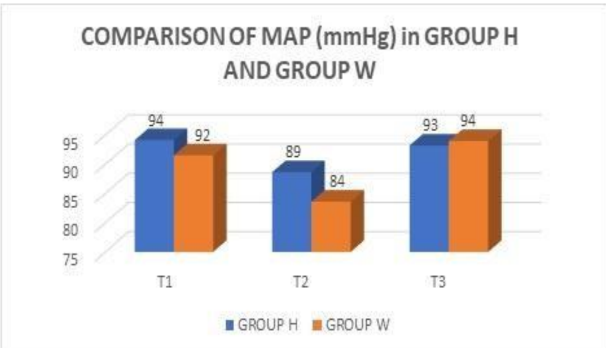

Fig. 5:Comparison of Average Mean arterial pressure (MAP) in patients of Group W and Group H at T1 (supine), T2 (10 min after prone position) and T3 (at the end of surgery before turning patient supine).

Average Intra-abdominal pressureat T1 was similar in both the groups. However mean IAP at T2 was higher in group W (12.73 ± 1.09) that that of group H (11.43 ± 1.48), difference being statistically significant (p = 0.006). Similar trend was observed at T3, IAP of group W (12.3 ± 1.13) was higher than that of group H (11.2 ± 1.08; p = 0.001).(Table 2, Figure 6)

	Group W (n = 30)		Group H (n = 30)		P - value
	Mean	SD	Mean	SD	
IAP 1	6.97	0.8	7.03	0.95	0.77
IAP 2	12.73	1.09	11.43	1.48	0.006
IAP 3	12.3	1.13	11.2	1.08	0.001

Table 2: Intra-abdominal pressures (IAP) of patients belonging to Group W and H at three different time points during lumbar spine surgery.

Values are Mean ± SD. Group W- Wilson's frame group, Group H- Horizontal bolster group. IAP- Intra-abdominal pressure IAP 1 –in supine position, after induction and placement of Foley's catheter; IAP 2 - ten minutes after proper positioning of the patient in prone position; and IAP 3 - at the end of surgery, before turning the patient supine. Statistically significant difference ($P < 0.05$).

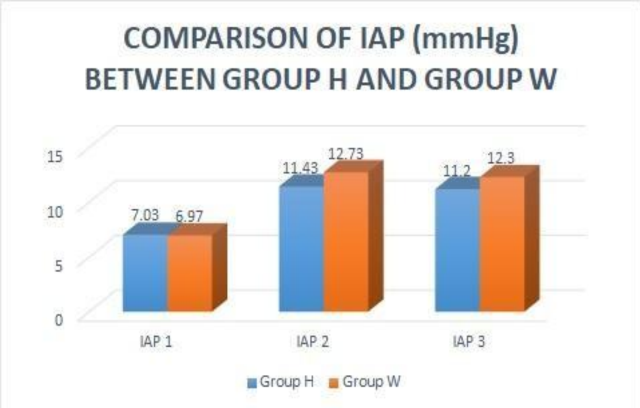

Fig. 6: Comparison of Intra-abdominal pressure (IAP) in patients of Group W and Group H at T1 (supine), T2 (10 min after prone position) and T3 (at the end of surgery before turning patient supine).

Comparatively higher airway pressures, plateau (16.33 ± 1.30 and 17.03 ± 1.22) and peak (18.27± 1.26 and 18.10± 1.78) were observed in Group W as compared to group H at T2 and T3. These variations were statistically significant with p value of <0.05 for both the time points. (Table 3)

	Group W (n=30)		Group H (n=30)		P - value
	Mean	SD	Mean	SD	
Plat 1	12.1	0.98	12.43	1.38	0.76
Plat 2	16.33	1.3	15.23	1.33	0.004
Plat 3	17.03	1.22	16.07	1.48	0.0002
	Group W (n=30)		Group H (n=30)		p - value
	Mean	SD	Mean	SD	
Peak 1	13.1	1.14	13.6	1.08	0.89
Peak 2	18.27	1.26	17.1	1.6	0.001
Peak 3	18.1	1.78	17.27	1.53	0.02

Table 3: Airway pressures (peak pressure and plateau) of patients belonging to Group W and H at three different time points during lumbar spine surgery.

Values are Mean ± SD. Group W- Wilson's frame group, Group H- Horizontal bolster group. Plat 1 and Peak 1 –Plateau pressure and Peak Pressure in supine position, after induction and placement of Foley's catheter; Plat 2 and Peak 2 - Plateau pressure and Peak Pressure ten minutes after proper positioning of the patient in prone position; and Plat 3 and Peak 3 - Plateau pressure and Peak Pressure at the end of surgery, before turning the patient supine respectively.Statistically significant difference ($P < 0.05$).

Blood loss of 223.33 ± 46.00 in group W was higher than average blood loss of 190.00 ± 50.79 in group H and the difference was statistically significant with p value of 0.006 for blood loss. (Fig. 7)

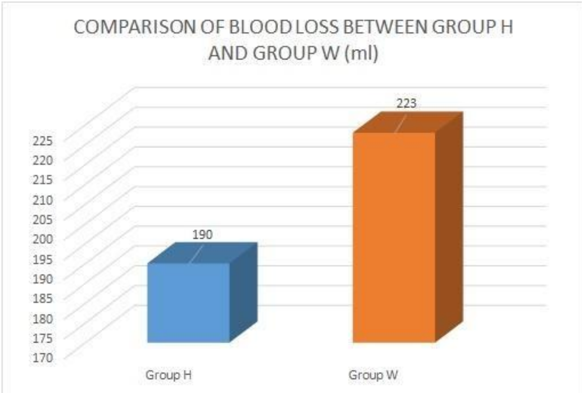

Fig. 7:Comparison of Blood loss in patients of Group W and Group H at the end of surgery.

DISCUSSION

Prone position is ideal for spinal surgeries as it provides adequate exposure of bony and spinal structures[1]. Prone positioning increases intra-abdominal pressures, airway pressures and bleeding at surgical site but improves ventilation by decreasing ventilation perfusion mismatch[1],[3].This study was conducted to compare commonly used frames to position the patients prone for lumbar spine surgeries. Non obese patients with BMI ≤ 30kg/m^2 were included in the study. IAP was measured by a method devised by Krohn et. al which is non-invasive, accurate and most commonly used method[5].

Average IAP of 7mmHg recorded in supine position for patients in both groups was within normal range 6 – 8 mmHg ($p = 0.77$). Average IAP increased on positioning patients prone in both the groups. Group W however exhibited a significantly greater rise in IAP at both the time intervals in prone position. Discrepancy in IAP in prone position can be due to different design of the 2 prone devices[6]. Reason for higher IAP with Wilson's frame could be compression of abdomen between the vertical bars despite best efforts to keep adequate width. Padded bars of Wilson's frame also exert additional pressure on chest and abdominal wall. Similar findings were observed in a study conducted by Eugene et. al[7]. They reported greater increase in IAP in prone position with Wilson's frame as compared to Jackson spinal table.

Average peak and plateau airway pressures were comparable in both the groups with patients in supine position. However, increase in airway pressures was significantly higher in patients positioned prone on Wilson's frame at T2 and T3. Prone position itself warrants higher airway pressures due to compression of abdomen[6]**.**Essam M et. al also reported increase in airway pressures in prone position during spinal surgery[8]. Greater increase in airway pressure in group W can be due to greater IAP which may be cause cranial shifting of diaphragm[9] thus requiring greater airway pressure for ventilation and poor compliance[10].

In supine position, the HR and MAP were comparable in both groups. However, at T2 patients of group H exhibited only marginal change in heart rate whereas HR of patients belonging to group W increased significantly at T2. Both groups exhibited fall in MAP at T2.This observation is significant since prone positioning reduces stroke volume due to compression of IVC putting

patients at risk for hypotension. A raised intrathoracic pressure reduces stroke volume without much change in HR and MAP as they are counter balanced by increase in pulmonary and systemic vascular resistance[6]. Improper prone positioning of patients might exacerbate these hemodynamic disturbances. Also, because both groups have a comparable hemodynamic profile, blood loss can be compared. Findings of our study equate with study conducted by Niti Manohar et. al on haemodynamic changes in prone position on patients undergoing cervical spine surgery under general anaesthesia in which they reported decrease in venous return and left ventricular compliance and increase in systemic vascular resistance reflected as increase in heart rate and decrease in blood pressure[11].
Calculated average blood loss of in group W was significantly higher than average blood loss in patients of group H ($p = 0.006$). finding of our study is in line with existing literature as was evidenced by Koh JC et. al. in a study conducted by them on patients undergoing lumbar spine surgeries in prone position, they concluded that blood loss is directly proportional to airway pressure[12]. Flooding of surgical field with blood is problematic for both surgeons and anaesthesiologists as it increases both operating time and hemodynamic instability. Greater blood loss in Group W can be attributed to higher IAP and airway pressures. Raised pressures compress IVC which creates back pressure and cause congestion of epidural venous plexus[13].

CONCLUSION

Horizontal bolsters proved to superior to Wilson's frame for prone position of patients undergoing lumbar spine surgeries in terms of lower IAP in prone position along with lower airway pressures and less blood loss as compared to that with Wilson's frame.

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