Original Study

A Simulation Study of the Factors Influencing the Risk of Intraoperative Slipping

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Abstract

This simulation study seeks to quantify the risk of intraoperative slipping associated with the use of Trendelenburg during minimally invasive gynecologic surgery. We found that heavier patients are more likely to slip and that the choice of antislip material had a significant impact on the propensity to slide in the lithotomy position.

Background: To identify the impact of weight, table surface, and table type on slipping in a simulation of minimally invasive gynecologic surgery. **Methods:** A mannequin was placed into increasing Trendelenburg until a slip was observed; the table angle at the time of the event was measured (slip angle). The influence of mannequin position (supine vs. lithotomy), weight, table surface, and model was evaluated. A linear regression model was used to analyze the data. **Results:** Mannequin weight, bed surface, and bed type all significantly impacted the slip angles. In general, higher mannequin weights tolerated significantly more Trendelenburg before slipping in the supine position but less in lithotomy compared to lower weights. In lithotomy, the disposable sheet and gelpad performed worse than the bean bag, egg crate foam, and bedsheet. There was no difference in slipping because of bed surface in the supine model. The Skytron operating table performed significantly better than the Steris operating table when tested with the bedsheet. **Conclusion:** Operative position, patient weight, and bed surface together influence the slipping propensity. In lithotomy, heavier patients were more prone to slipping while the inverse was true in supine. The egg crate foam, bean bag, and bedsheet were the best antislip surfaces. Operating room table choice can mitigate slippage.

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Introduction

Laparoscopic surgery has become increasingly important in the drive to reduce patient morbidity. The introduction of robotic surgery has only served to accelerate this trend by allowing more complex surgeries to be performed using a minimally invasive technique. A key requirement of any minimally invasive gynecologic procedure is adequate visualization of the pelvis. This necessitates moving the bowel into the upper abdomen which is facilitated by placing patients in the Trendelenburg position. Steep Trendelenburg in the range of 30°-40° has historically been referenced as necessary for adequate visualization, but modern studies have found 16°-28° to be adequate.[1,2] Increasing levels of patient obesity, which often require a greater degree of Trendelenburg, are not fully addressed in these studies.

The question of how much Trendelenburg can safely be used before a patient slips down the table has not been well studied. The potential morbidity associated with patient movement on the operating room (OR) table is not insignificant and includes dislodged airways, cervical spine hyperextension, and neurologic injury.[3,4] Of additional concern for robotically treated patients is the possibility of intra-abdominal injury or tearing of skin incisions by fixed robotic instruments if the patient moves on the table.[5]

We aim to identify the bed material on which the greatest amount of Trendelenburg can be safely achieved as modified by other factors such as patient weight and bed type.

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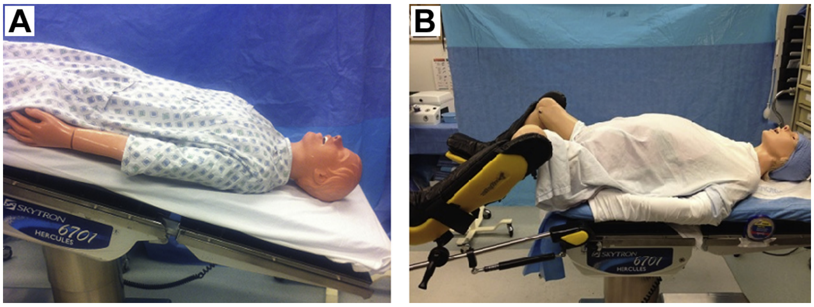
Figure 1 Mannequins Set Up for Testing in (A) Supine and (B) Lithotomy Position. Long Way Down



Methods

Institutional review board exclusion was granted. The experimental models used in this study were designed to replicate the conditions experienced by patients during laparoscopic surgery.

Mannequins similar in height to an average female were obtained to function as human surrogates. Specifically, in the supine model, a WMD/CBRNE/DECON full-body trainer mannequin (Simulaid, Saugerties, NY) was used. A Noelle Maternal Birthing simulator S551 (Gaumard, Miami, FL) was used for the lithotomy model because of greater range of motion in the hips allowing for better placement in Allen stirrups and its ability to hold a greater amount of weight than the Simulaid mannequin (Figure 1).[6] The portion of the mannequin in contact with the bed surface was made of a combination of rubberized silicone and polyvinylchloride. The coefficient of friction is variable dependent on a variety of surface interactions, and the manufacturer does not have the information for their propriety materials. Given the tackiness and texture of the material, baby powder, which lowers the coefficient of friction, was used on the mannequin's surface to help it better approximate human skin.[7-9] The mannequins were then positioned in either supine or lithotomy position with their arms tucked. When in lithotomy, the mannequin's legs were placed in Yellowfin Elite Stirrups (Allen, Acton, MA).

A variety of mannequin weights were tested. A starting weight of 100 lbs was increased in 50-lbs increments to a maximum of 250 lbs in the supine and 300 lbs in the lithotomy model because this mannequin was able to hold more weight without being damaged. The weight was evenly distributed across the mannequin's torso (hips to shoulders) and arms to limit the effect of weight being concentrated toward the pelvis or shoulders as a source of error.

The OR table was covered with the selected surface. The bedsheet served as our baseline surface as this best represented a typical OR set up. The other surfaces tested, except for the disposable sheet which was used in isolation, were laid on top of the bedsheet. The egg crate foam was further secured to the sheet with tape. In the case of the bean bag, which is the only surface tested that did not lie flat on the bed, the mannequin was cradled in the bean bag and suction was applied to lock it in place. The addition of egg crate foam or a gelpad to the bedsheet was selected for testing as they are 2 common approaches to limit slipping currently used clinically. Two additional surfaces, a bean bag and a disposable bedsheet (Microtek Disposable sheet Model #ABTSLSCF; Microtek Medical, Columbus, MS), were also evaluated in the lithotomy model as our hospital recently introduced a slick disposable sheet in the OR that anecdotally increased slipping.

Two OR tables were used in our testing. An AMSCO 3085 SP (Steris, Mentor, OH) and a 6701 Hercules (Skytron, Grand Rapids, MI) were both used in the supine testing and only the Skytron in the lithotomy testing. The maximum amount of Trendelenburg available on Steris and Skytron beds were 25° and 30°, respectively.

To replicate a sliding event, the angle of Trendelenburg was increased until the mannequin was noted to slip. A slip was defined as any movement of the mannequin down the slope toward the head of the table. The slip angle was defined as the angle of the bed from the horizontal when slipping was first observed and was measured using a Swanson angle finder attached to the OR table and repeated in triplicate. All measurements were performed by the same examiner to limit variability. For each combination of treatment conditions, the average slip angle from three consecutive runs was analyzed.

Linear regression models were used to analyze the effect of bed surface, weight, and bed type. Model-based estimates of treatment-level differences were computed, and P values were obtained. All analyses were performed using SAS 9.3 (Cary, NC). Significance tests were evaluated using a type I error rate of 0.05.

Results

Supine Model

The slip angle for each surface is presented in Table 1. An analysis of the effect of mannequin weight and bed surface (Table 2)

Table 1 The Effect of Bed Surface and Mannequin Weight on Slip Angle in the Supine Position

Weight Comparisons (lbs)	Mannequin Slip Angle (Degrees)		
	Bedsheet	Egg Crate Foam	Gelpad
100	23.0	23.7	24.3
150	21.3	23.3	21.7
200	22.7	22.7	21.7
250	28.7	25.0	23.7