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Curvilinear Supine Position for the Prevention of Intraoperative Pressure Injury: A Meta-Analysis

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ADMINISTRATIVE INFORMATION**Support** - Not applicable.**Review Stage at time of this submission** - Completed but not published.**Conflicts of interest** - None declared.**INPLASY registration number:** INPLASY2026100108**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 26 October 2026 and was last updated on 26 October 2026.**INTRODUCTION**

Review question / Objective Objective: To systematically evaluate the effectiveness of the curvilinear supine position versus the traditional supine position or routine positioning care for preventing intraoperative pressure injuries in patients undergoing supine surgery, with the primary outcome being pressure injury incidence and secondary outcomes being pressure injury staging and interface pressure at anatomical sites.

Condition being studied The condition being studied is intraoperative acquired pressure injury, defined as localised damage to the skin and/or underlying soft tissue caused by pressure, shear forces, or friction during surgical procedures, typically occurring over bony prominences. Surgical patients represent a high-risk population for pressure injuries because of anaesthesia-induced sensory loss, prolonged immobility in fixed positions, extended operative duration, intraoperative hypothermia, and haemodynamic

instability. Studies cited in the manuscript report that the incidence of pressure injuries exceeds 8.5% in patients undergoing surgery lasting more than 3 hours, with the risk of tissue damage increasing by 33% for every additional 30 minutes of operative time. Pressure injuries not only cause pain and increase the risk of infection but also prolong hospital stays, escalate healthcare costs, and may even lead to sepsis in severe cases, rendering them a critical quality indicator of perioperative nursing care.

Current clinical measures for preventing intraoperative pressure injuries primarily include preoperative risk assessment, the use of pressure-redistributing support surfaces such as gel pads and foam dressings, local skin protection, intraoperative temperature management, and regular repositioning. However, these strategies have inherent limitations: support surfaces may deform over time and diminish their pressure-relieving efficacy, and frequent repositioning may interfere with surgical procedures and increase the risk of sterile field contamination. The review

focuses on patients undergoing surgery in the supine position and evaluates pressure injury incidence, pressure injury staging (Stage I–IV), and interface pressure at anatomical sites including the sacral, heel, scapular, occipital, and calf regions.

METHODS

Participant or population The review addressed patients undergoing surgery in the supine position. The inclusion criteria imposed no restrictions on age, sex, nationality, surgical type, or operative duration. Eligible participants were patients enrolled in randomized controlled trials in which the experimental group received the curvilinear supine position, either applied alone or combined with other routine preventive measures such as air mattresses or foam dressings, and the control group received the traditional supine position or routine positioning care.

Across the 11 included randomized controlled trials published between 2017 and 2025, the participant populations comprised patients undergoing supine surgery across varied surgical types, including orthopaedic, neurosurgical, and abdominal surgeries. The included study populations reported in the manuscript encompassed patients after orthopaedic surgery, patients after decompressive craniectomy for hypertensive intracerebral haemorrhage, patients after total hip arthroplasty, elderly postoperative patients, and long-term bedridden or postoperative bedridden patients. The review did not restrict participants by age, sex, nationality, surgical type, or operative duration; the included trials were conducted in China except for one conducted in Iran.

Intervention The intervention evaluated in this review was the curvilinear supine position, a positioning strategy applied to patients undergoing surgery in the supine position. In the included randomized controlled trials, the experimental group received the curvilinear supine position either applied alone or combined with other routine preventive measures, such as air mattresses or foam dressings. The control group received the traditional supine position or routine positioning care.

The curvilinear supine position involves elevating the head and back plates of the operating table by approximately 10° and lowering the leg plate by approximately 10°, positioning the buttocks at the lowest point. This adjustment increases the contact area between the body and the operating table, thereby achieving pressure redistribution.

The intervention is described as requiring only adjustment of the operating table angles without additional materials, and as not compromising surgical field exposure or surgical manipulation. Its underlying mechanism is pressure redistribution, transferring pressure from bony prominences to muscle-rich areas. In the interface pressure findings, the curvilinear supine position significantly reduced sacral, occipital, and heel pressures while increasing calf pressure, with no significant change in scapular pressure. Across the included studies, the curvilinear supine position was employed as the intervention with a consistent underlying mechanism of pressure redistribution.

Comparator The comparator in this review was the traditional supine position or routine positioning care. According to the inclusion criteria, the control group received the traditional supine position or routine positioning care, rather than the curvilinear supine position as a positioning strategy. The included randomized controlled trials compared the curvilinear supine position with the traditional supine position or routine care. The experimental group received the curvilinear supine position, either applied alone or combined with other routine preventive measures such as air mattresses or foam dressings, whereas the control group received the traditional supine position or routine positioning care. Thus, the principal distinction between the intervention and comparator was whether the curvilinear supine position was applied.

Study designs to be included Randomized controlled trials (RCTs) were included, with no language restrictions. Eligible RCTs compared the curvilinear supine position with the traditional supine position or routine care in patients undergoing supine surgery. Duplicate publications or studies with incomplete data where the full text was unavailable were excluded.

Eligibility criteria No additional inclusion criteria beyond those defined in the PICOS sections were specified. The search was limited to randomized controlled trials, and animal studies were excluded. Additional exclusion criteria were: duplicate publications; and studies with incomplete data where the full text was unavailable.

Information sources A systematic literature search was conducted across six electronic databases: PubMed, Web of Science, Cochrane Library, Embase, Scopus, and the China National Knowledge Infrastructure (CNKI). The databases were searched from inception to 1 March 2026. The search strategy combined Medical Subject

Headings and Emtree terms with free-text terms, covering pressure injuries, position (e.g., supine position, flat position), curvilinear positioning and pressure redistribution, and the surgical population (e.g., surgery, intraoperative, perioperative). The search was limited to randomized controlled trials, and animal studies were excluded.

Main outcome(s) The primary outcome was pressure injury incidence, assessed across the 11 included randomized controlled trials. Pressure injury incidence was evaluated including immediately after surgery, postoperative day 1, day 2, day 3, or during hospitalisation. For this dichotomous outcome, the odds ratio (OR) with 95% confidence interval (CI) was used as the effect measure. The pooled effect showed that the curvilinear supine position group had a significantly lower incidence of pressure injury than the control group (OR = 0.15, 95% CI: 0.09–0.26, $P < 0.001$; $I^2 = 0\%$).

Secondary outcomes were pressure injury staging and interface pressure at anatomical sites. Pressure injury staging was reported as Stage I–IV, and subgroup analyses by stage showed significant reductions for Stage I (OR = 0.27, 95% CI: 0.13–0.55), Stage II (OR = 0.27, 95% CI: 0.10–0.71), and Stage III (OR = 0.23, 95% CI: 0.06–0.82), but not for Stage IV (OR = 0.33, 95% CI: 0.05–2.10). Interface pressure was assessed at five anatomical sites (sacral, heel, scapular, occipital, and calf regions) across four RCTs; as all studies used consistent measurement units (mmHg), the standardised mean difference (SMD) was used as the effect measure. The curvilinear supine position significantly decreased sacral pressure (SMD = -0.81, 95% CI: -1.10 to -0.53), heel pressure (SMD = -1.38, 95% CI: -1.59 to -1.18), and occipital pressure (SMD = -0.23, 95% CI: -0.41 to -0.04) while increasing calf pressure (SMD = 1.14, 95% CI: 0.94–1.34); no significant difference was observed for scapular pressure.

Quality assessment / Risk of bias analysis The methodological quality of the included randomized controlled trials was assessed using the Cochrane risk-of-bias tool. Two independent reviewers evaluated the risk of bias across the following seven domains: (1) random sequence generation, (2) allocation concealment, (3) blinding of participants and personnel, (4) blinding of outcome assessment, (5) incomplete outcome data, (6) selective reporting, and (7) other bias. Each domain was categorised as “low risk,” “high risk,” or “unclear” based on predefined criteria. Disagreements during the evaluation process were

resolved through discussion or consultation with a third reviewer.

The overall risk of bias for each study was determined according to the Cochrane risk-of-bias tool algorithm as follows: (1) low risk of bias — all domains were rated as low risk; (2) some concerns — any domain was rated as having some concerns, with no domain rated as high risk; and (3) high risk of bias — any domain was rated as high risk. The assessment results were visualised using a risk-of-bias summary figure, and risk-of-bias graphs were generated using RevMan 5.4 software. In the manuscript, the overall risk of bias among the 11 included studies was reported as low, with no studies rated as high risk. The certainty of evidence for each outcome was additionally assessed using the GRADE approach, rated as high, moderate, low, or very low based on risk of bias, inconsistency, indirectness, imprecision, and publication bias, with assessments presented in Supplementary Table 3.

Strategy of data synthesis Meta-analysis was performed using Stata 17.0 software (StataCorp LLC, College Station, TX, USA). For dichotomous outcomes, the odds ratio (OR) with its 95% confidence interval (CI) was used as the effect size. For continuous outcomes (interface pressure at anatomical sites), the standardised mean difference (SMD) was used as the effect size. A two-tailed $P < 0.05$ was considered statistically significant.

Heterogeneity among studies was assessed using the I^2 statistic: I^2 75% indicated high heterogeneity. For the interface pressure analysis, significant heterogeneity was detected in the overall analysis ($I^2 = 94.7\%$, $P < 0.001$); therefore, a random-effects model was used.

The following subgroup analyses were prespecified based on potential sources of clinical heterogeneity and the analytical needs of the results section: (1) by pressure injury stage, to evaluate the preventive effect of the curvilinear supine position on pressure injuries of varying severity; and (2) by anatomical site, to evaluate the effect of the curvilinear supine position on interface pressure at different anatomical sites.

Sensitivity analysis was conducted using the leave-one-out method to evaluate the robustness of the pooled results. For instances where a single study contributed multiple effect sizes (e.g., reporting multiple stage-specific data in the staging subgroup analysis), robust variance estimation (RVE) was employed to correct for

potential unit-of-analysis errors. RVE analysis used a random-effects weighting scheme (weighttype(random)) with study-level clustering to adjust for the correlation among effect sizes from the same study. RVE analyses were conducted using the robumeta command in Stata 17.0.

Publication bias was assessed using funnel plots in conjunction with Begg's rank correlation test and Egger's regression test. When the number of included studies was ≥ 10 , both Begg's test and Egger's test were performed; when the number was < 10 , only funnel plot visual inspection was used, as statistical tests would have insufficient power. Risk of bias graphs were generated using RevMan 5.4 software. The certainty of evidence for each outcome was assessed using the GRADE approach, with assessments presented in Supplementary Table 3.

Subgroup analysis The following subgroup analyses were prespecified based on potential sources of clinical heterogeneity and the analytical needs of the results section: (1) by pressure injury stage, to evaluate the preventive effect of the curvilinear supine position on pressure injuries of varying severity; and (2) by anatomical site, to evaluate the effect of the curvilinear supine position on interface pressure at different anatomical sites.

For pressure injury staging, as some studies reported staging data at multiple time points, analyses were stratified by stage category and measurement time point. Subgroup analyses were stratified by pressure injury stage (Stage I, II, III, and IV), with pooled effect sizes calculated using random-effects models. Because a single study could contribute multiple effect sizes in the staging subgroup analysis, robust variance estimation (RVE) was employed to correct for potential unit-of-analysis errors, using a random-effects weighting scheme with study-level clustering.

For interface pressure, subgroup analyses were performed by anatomical site across five sites (sacral, heel, scapular, occipital, and calf regions). Subgroup analysis revealed moderate-to-high heterogeneity in the sacral pressure subgroup ($I^2 = 52.3\%$, $P = 0.098$), whereas no significant heterogeneity was observed in the other subgroups ($I^2 = 0\%$).

Sensitivity analysis Sensitivity analysis was conducted using the leave-one-out method to evaluate the robustness of the pooled results. This analysis was performed for the primary outcome of pressure injury incidence, for pressure injury

staging, and for interface pressure at anatomical sites. The results showed that the pooled effect size remained stable after excluding any single study, indicating that the meta-analysis results were robust and reliable. These findings are presented in Supplementary Figure 2 (pressure injury incidence), Supplementary Figure 4 (pressure injury staging), and Supplementary Figure 6 (interface pressure at anatomical sites). In addition, for the staging subgroup analysis, robust variance estimation (RVE) was employed to address the potential unit-of-analysis error arising from multiple effect sizes contributed by the same study; the RVE-corrected results were consistent with the original analysis, further supporting the robustness of the primary staging subgroup findings.

Country(ies) involved China.

Keywords pressure injury; supine position; intraoperative complications.

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