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Rapid Review

Pressure injury prevention in the operating theater

Citation Garrubba, M & Joseph, C. 2016. Pressure injury prevention in the operating theater: Rapid Review. Centre for Clinical Effectiveness, Monash Health, Melbourne, Australia.

Executive Summary

Background

Pressure ulcers are ulcers on the skin caused by pressure or rubbing of the skin at points of weight bearing, or bony prominences of immobilised patients (NICE, 2014). There are a range or interventions that can be used to reduce the incidence of pressure ulcers which include screening tools and support surfaces however, it is currently unknown which of these are most beneficial to patients in the operating theatre.

Objective

The objective of this report was to rapidly review the evidence and provide a summary regarding pressure injury prevention in the operating theatre. In particular, we were interested in: 1) risk screening tools (pre and during) and interventions (pre, during, post) surgery.

Search Strategy

Searches of Medline, Google and the Cochrane Library were conducted from 2011 onward. Guidelines, systematic reviews, RCTs and other comparative studies were included.

Search Results

Searches resulted in 534 items. Three systematic reviews and two clinical practice guidelines were identified and included in this review.

Key pieces of information included:

A NICE guideline provided evidence and recommendations for effective screening tools to assess patient's risk of pressure injury during surgery (NICE, 2014).

The National Pressure Ulcer Advisory Panel provided evidence and recommendations for effective interventions to prevent pressure injuries in the operating theater during surgery. (National Pressure Ulcer Advisory Panel, 2014)

A systematic review (McInnes et al., 2015) provided evidence about pressure-redistribution or support surfaces for pressure ulcer prevention (intra-operatively and post-operatively)

Summary

What are effective screening tools to assess patient's risk of pressure injury during surgery?

- Recommendations are to consider using a validated scale to support clinical judgement (e.g. the Braden scale, the Waterlow score, Norton risk-assessment scale, etc.) when assessing pressure ulcer risk. There is currently no evidence exploring best-practice for screening tools in surgical patients (NICE, 2014).
- Low quality evidence was identified and informal consensus was used to develop this recommendation (NICE, 2014)

What are effective interventions to prevent pressure injuries in the operating theater during surgery?

<u>General recommendations</u> (National Pressure Ulcer Advisory Panel, 2014)

- Use additional support surfaces (e.g., facial pads) to offload pressure points on the face and body while in the prone position.
- Use heel suspension devices that elevate and offload the heel completely in such a way as to distribute the weight of the leg along the calf without placing pressure on the Achilles tendon.
- Consider pressure redistribution prior to and after surgery.

- Place the individual on a high specification reactive or alternating pressure support surface both prior to and after surgery.

Position

- It is recommended to position the individual in such a way as to reduce the risk of pressure ulcer development during surgery. (National Pressure Ulcer Advisory Panel, 2014)
- It is recommended to ensure that the heels are free of the surface of the operating table. (National Pressure Ulcer Advisory Panel, 2014)
- It is recommended not to position the individual directly on a medical device unless it cannot be avoided. (National Pressure Ulcer Advisory Panel, 2014)
- It is recommended to position the knees in slight flexion when offloading the heels. (National Pressure Ulcer Advisory Panel, 2014)
- It is recommended to position the individual in a different posture preoperatively and postoperatively than the posture adopted during surgery. (National Pressure Ulcer Advisory Panel, 2014)

Pressure-redistribution or support surfaces for pressure ulcer prevention

Intra-operatively

- A pressure-reducing mattresses used intra-operatively *and* post-operatively prevents pressure ulcers (Huang et al., 2013)
- Viscoelastic polymer pad operating table overlays reduce the incidence of post-operative pressure ulcers (47%) compared to a standard operating table. (McInnes et al., 2015)
- It is unclear if a pressure-reducing mattress intra-operatively alone prevents pressure ulcers. It should be noted that one study (Feuchtinger et al., 2006) found patients placed on an operating table foam overlay experienced slightly more pressure ulcers (17.6%) than patients on the standard operating table without the foam overlay (11.1%), adverse results that caused the termination of the RCT. (Huang et al., 2013)
- There is no difference in a micropulse alternating system (applied both during surgery and postoperatively) with a gel pad during surgery was compared to a standard mattress post-operatively for pressure relief. (McInnes et al., 2015)
- There are tentative indications that interventions may be harmful. An alternative foam overlay used in the operating theatre suggests that patients were significantly more likely to experience postoperative skin changes (i.e.mainly grade 1 pressure ulcers). Further, a trial was terminated comparing an operating theatre table that included a water-filled warming mattress and a 4-cm thermoactive viscoelastic foam overlay with an operating theatre table with a water-filled warming mattress only. The trial was terminated before the full sample was recruited because more patients in the group receiving the 4-cm thermoactive viscoelastic foam overlay developed pressure ulcers (all were grades 1 to 2). (McInnes et al., 2015)
- Use a high specification reactive or alternating pressure support surface on the operating table for all individuals identified as being at risk of pressure ulcer development. (National Pressure Ulcer Advisory Panel, 2014)

Post-operatively

- A pressure-reducing mattress post-operatively prevents pressure ulcers (Huang et al., 2013; McInnes et al., 2015).
- Cubed foam mattress used post-operatively reduce the incidence and severity of pressure ulcers in patients a high risk of pressure ulcers (McInnes et al., 2015)
- There is no difference between constant low pressure devices (e.g. water mattress, foam pad, static air mattresses) compared to different types of alternating-pressure supports postoperatively in pressure ulcer incidence rates (McInnes et al., 2015)
- There is no benefit of using a series of various combinations of standard, constant low-pressure (Tempur), or an alternating-pressure (Nimbus) support post-operatively to reduce pressure ulcers (McInnes et al., 2015)
- There is no difference between air-fluidised beds and dry flotation mattress' in post-operative tissue breakdown rates (McInnes et al., 2015)
- There is no benefit of kinetic beds compared to conventional beds on the incidence of pressure ulcers (McInnes et al., 2015)
- It is recommended that consideration be given to the use additional support surfaces (e.g., facial pads) to offload pressure points on the face and body while in the prone position (National Pressure Ulcer Advisory Panel, 2014)
- It is recommended that consideration be given to pressure redistribution prior to and after surgery (National Pressure Ulcer Advisory Panel, 2014)

- It is recommended to place the individual on a high specification reactive or alternating pressure support surface both prior to and after surgery (National Pressure Ulcer Advisory Panel, 2014)

Dressings as an adjunct to pressure ulcer prevention (Black et al., 2015; Moore & Webster, 2013)

- Pressure ulcer prevention should begin in the Emergency Department for patients likely to be admitted for surgery or to critical care units.
- Consider the use of a five-layer soft silicone bordered foam dressing to enhance, but not replace, pressure ulcer prevention strategies for the sacrum, buttock and heel.
- Before selecting a dressing, consider the current status of the skin and the ease of dressing removal in order to prevent mechanical stripping.
- Consider placement of five-layer soft silicone bordered foam dressing to the buttocks and sacrum prior to prolonged procedures or anticipated events when the patient cannot move or be moved from the supine position.
- It is concluded that evidence on the effectiveness of five-layer soft silicone bordered dressing (Mepilex®) supports its use as a component of sacral pressure ulcer prevention in patients at high risk of pressure ulcers, those in the ED, ICU and OR. However, a high quality review (Moore and Webster, 2013) stated that there is a high or uncertain risk of bias, and therefore, firm conclusions cannot be made regarding the use of dressings to prevent pressure ulcers.

Quality of evidence

Mixed quality was observed. No publication bias was present. Furthermore, the nature of a rapid review and hence, this report means that the methods used were by no means exhaustive and this should be kept in mind.

Conclusions

Currently, it is unknown which pressure ulcer risk assessment scale is best for patients undergoing surgery.

Evidence suggests the use of a validated scale in conjunction with clinical judgement is best. A high specification pressure reducing mattress both intra-operatively *and* post-operatively is effective in reducing the incidence of pressure ulcers. The majority of materials are effective however, caution should be exercised regarding the use of a foam overlay or 4-cm thermoactive viscoelastic foam overlay as they may cause more pressure ulcers.

Furthermore, a five-layer soft silicone bordered dressing for the sacrum, buttock and heel should be used to enhance, but not replace, other pressure ulcer reducing strategies. Consideration on the use of dressings should be given to patients who may be at risk of mechanical stripping the skin when removing the dressing.

Background

Pressure ulcers are ulcers on the skin caused by pressure or rubbing of the skin at points of weight bearing, or bony prominences of immobilised patients (NICE, 2014). “Pressure ulcers are often difficult to heal, painful and impact negatively on the individual’s quality of life. The cost implications of pressure ulcer treatment are considerable, compounding the challenges in providing cost effective, efficient health services. There are a range or interventions that can be used to reduce the incidence of pressure ulcers which include screening tools, dressing and support surfaces. Support surfaces include beds, mattresses, mattress overlays, and cushions that are aimed to reduce on the skin in contact with the surface (McInnes et al., 2015). Dressing can also be placed on vulnerable areas to protect the skin from damage (Moore & Webster, 2013). Importantly, there are also a number of risk assessment tools that can be used to determine the level of risk that a patient has in developing a pressure ulcer (NICE, 2014). There is some evidence of interventions for pressure ulcer prevention (McInnes et al., 2015) however, it is currently unknown which of these interventions and risk assessment tools are most beneficial to patients in the operating theatre. The objective of this report was to rapidly review the evidence and provide a summary regarding pressure injury prevention in the operating theatre.

Questions

In particular, we were interested in the evidence and effectiveness of: A) The risk screening tools used for ulcer prevention in surgical patients, both pre and during surgery; and B) The interventions used to prevent pressure ulcers pre, during, and post-surgery.

Inclusion Criteria

Population	**Include:** Individuals (Adults) without pressure injuries or considered at risk of developing pressure injuries not limited by age
Interventions	**Include:** Any including risk screening tools
Setting	**Include:** Operating theater **Exclude:** all other settings
Outcome	1. Identification of surgical patients at risk of pressure injuries in the operating theater 2. Prevention of pressure injuries in patient
Types of evidence	**Include:** Guidelines, Systematic Reviews, RCTs and other comparative studies.
Limits	**Date**: 2011 – current (December 2016) **Language:** Publications in English

Search strategy

Question 1a: What are effective screening tools to assess patient’s risk of pressure injury during surgery?

A scoping search identified a Cochrane Systematic Review published in 2014 that reported on ‘Risk Assessment Tools for the Assessment of Pressure Ulcers’. The search strategy of this review was current as of December 2013. We searched forward from this date in Medline, Google and the Cochrane Library to identify any new resources to include.

Guidelines identified in a previous search conducted by Yap 2016 were also screened for information relevant to screening tools to assess patient’s risk of pressure injury during surgery. Full details are available in Appendix 1.

Question 1b: What are effective interventions to prevent pressure injuries in the operating theater during surgery?

A systematic search of Medline, Google and the Cochrane Library was undertaken using appropriate terms for pressure injury, pressure ulcer, prevention, surgery and operating theater. Full details are available in Appendix 1.

Guidelines identified in a previous search conducted by Yap 2016 were also screened for information relevant to interventions to prevent pressure injuries in the operating theater during surgery.

Any article identified that did not specify, or make clear recommendations for practice in a surgical context was not included in this review.

Results

Screening tools to assess patient's risk of pressure injury during surgery

Searches resulted in 534 items. Searching of Medline retrieved 226 results. Review of titles, abstracts and retrieval of full text articles identified no additional studies to include.

Searching of the Cochrane Library retrieved 32 results. Review of titles, abstracts and full text did not identify any additional studies or reviews.

Searching Google retrieved 276 results. No new evidence relevant to risk assessment for pressure injury during surgery was identified.

Clinical Practice Guidelines

One resource (NICE, 2014) from a previous review (Yap, 2016) that were not identified in the searches but were included in the review. Table 1 provides a summary of evidence of this guideline.

Table 1. Summary of evidence for clinical practice guidelines.

Resource	Findings
NICE, 2014.	"The GDG discussed the evidence relating to the use of risk assessment tools in the prevention of pressure ulcers. The GDG felt that there were potential benefits of using a risk assessment tool to identify an individual's risk of developing a pressure ulcer, and then using the results of risk assessment to ensure that targeted preventative treatment was provided. For example, the results of a risk assessment may help to inform the frequency or position of repositioning or whether a pressure redistributing device is to be used. The GDG were not confident in the direct RCT evidence comparing the Braden scale plus preventative treatment versus clinical judgement plus prevention. The quality of evidence according to GRADE rating was very low and potentially flawed in 1 study, and there was a risk of contamination in another. The evidence in the latter suggested that there was no clinically important difference between clinical judgement versus either the Waterlow scale or the Ramstadius scale. In Part 2 of the review, there was much variability across studies in the predictive ability of each tool, and there was probable confounding by the use of preventative treatments. The main tools of Braden, Waterlow and Norton gave only moderate areas under the curve, and low to moderate sensitivities at standard thresholds. However, there was much heterogeneity. The GDG took into consideration the ROC curve analysis at standard thresholds. This suggested that there was little difference between the 3 main tools and, tentatively indicated that all were better tests than clinical judgement (although there were only 2 studies reporting clinical judgement). However, there was much heterogeneity. The GDG highlighted that the need to use a formal risk assessment tool was further supported by anecdotal evidence that healthcare professions varied in their levels of skill and experience. Therefore, it was not possible to recommend the use of clinical judgement alone to identify whether an individual was at risk of developing a pressure ulcer. Furthermore, the GDG thought that the formal process of using a risk assessment tool would ensure that pressure ulcer risk was documented and acknowledged as a significant issue. In addition, the process of undertaking pressure ulcer risk assessment was regarded as a positive patient contact point, and thus providing an opportunity to address other concerns that the individual may have. The GDG felt that all people are considered to be potentially at risk of developing a pressure ulcer. Therefore all healthcare professionals need to be aware of this potential risk. All patients in secondary care, or care homes where NHS care is provided, should receive a risk assessment on admission. The GDG developed a subsequent recommendation to encapsulate all other situations, including those who receive on-going care in other NHS care settings such as primary care, community care or emergency departments. The GDG felt that in these settings, individuals who have a risk factor should be considered for a risk assessment, as there were individuals within these settings who may not be considered potentially

	at risk of developing a pressure ulcer. The GDG emphasised that this also includes individuals who are waiting to receive care, for example in an outpatient department may also be at risk. This led the GDG to outline the examples of clinical risk factors which should lead to a risk assessment being carried out. It is by no means intended that this list is exhaustive and healthcare professionals should exercise clinical judgement at all times in identifying relevant risk factors. The GDG then considered whether to recommend a tool in preference to another. They noted that the evidence from the head-to-head comparisons within individual studies showed that there was not much difference between existing tools. Therefore, although the GDG felt that healthcare professionals should use a validated risk assessment tool, they did not feel that there was strong enough evidence to recommend the use of a specific risk assessment tool, and consequently provided 3 commonly used tools as examples; the Braden scale, the Waterlow score and the Norton risk- assessment scale. **Quality of the evidence** The quality of the evidence was generally very low according to the GRADE criteria. In Part 1, the GDG noted the lack of baseline comparability for preventative treatment in the Saleh study, and were also aware of contamination issues in the Webster study, such that nursing staff could have improved their clinical judgement by learning from the risk tool. In Part 2, the quality of the evidence was again very low, with confounding by preventative treatment occurring in a number of studies, with inconsistency across studies in the preventative treatment given. The effect of giving preventative treatment was likely to have an impact on the statistical measures, and this was not taken into account in the authors' analyses, with two exceptions. In the prognostic review, there was considerable heterogeneity that could not be explained."

Interventions to prevent pressure injuries in the operating theater during surgery

The search of Medline identified 175 results from 2013 onwards. Review of titles, abstracts and full text and identified 3 reviews and 2 clinical practice guidelines. Table 2 provides a summary of evidence relating to interventions to prevent pressure injuries specifically in the surgical context and Table 3 provide a summary of the clinical practice guidelines.

Table 2. Summary of interventions to prevent pressure injuries pre, during, or post-surgery

Resource	Findings
Black et al., 2015	**Key message** Pressure ulcer prevention should begin in the Emergency Department for patients likely to be admitted for surgery or to critical care units **Recommendations** 1. Consider the use of a five-layer soft silicone bordered foam dressing to enhance, but not replace, pressure ulcer prevention strategies for the sacrum, buttock and heel (SOE=A). Evidence: Brindle and Wegelin followed up 93 surgical trauma ICU patients considered to be at risk of pressure ulcers and treated preventively with a five-layer soft silicone bordered dressing on the sacrum. Of the 41 patients provided with the wound dressing, none developed sacral pressure damage whereas 3 of 52 patients considered to be less vulnerable to pressure ulcer development experienced sacral pressure ulcers. 2. Before selecting a dressing, consider the current status of the skin and the ease of dressing removal in order to prevent mechanical stripping (SOE=B). Evidence: Skin injury can result from repeated removal of strongly adhesive dressings. If skin is torn, easily bruised or fragile use a dressing such as soft silicone which is recognised to prevent skin damage. For patients with fragile skin, use of a retention bandage to hold the dressing securely in place is recommended. 8. Consider placement of five-layer soft silicone bordered foam dressing to the buttocks and sacrum prior to prolonged procedures or anticipated events when the patient cannot move or be moved from the supine position (SOE=B). **Conclusion** Evidence on the effectiveness of five-layer soft silicone bordered dressing (Mepilex®) supports its use as a component of sacral pressure ulcer prevention in patients at high risk of pressure ulcers, those in the ED, ICU and OR.
Mc Innes et al., 2015	The results of three of the five trials evaluating the use of pressure- relieving overlays on the operating table suggest that these are beneficial in reducing subsequent pressure ulcer incidence in high-risk surgical patients. These three trials were of reasonable or good quality; in particular the Nixon 1998 trial was adequately powered, with allocation concealment and blinded outcome assessment lending further weight to the result. At present, the most effective means of pressure relief on the operating table is unclear; Nixon and colleagues found a gel-filled overlay to be significantly better than a standard operating table, whilst a gel-filled overlay on the operating table was less effective than an alternating-pressure overlay intra- and postoperatively (the Micropulse system) in the other two trials (Aronovitch 1999; Russell 2000). The Micropulse trials were confounded by their provision of a standard mattress postoperatively in the gel overlay arm, and an alternating-pressure overlay postoperatively in the Micropulse arm. Thus whilst there is clearly a reduction in pressure ulcer incidence associated with the alternating-pressure system, it is not clear whether this is merely a result of better postoperative pressure relief. Two other trials showed that postoperative skin changes occurred as a result of different operating theatre overlays (Feuchtinger 2006; Schultz 1999), but the clinical importance of these results is difficult to determine in the absence of further details about pressure ulcer grading and products used. There are tentative indications that four interventions may be harmful. Thirdly, Schultz 1999 investigated the effectiveness of an alternative foam overlay used in the operating theatre; the results suggested that patients placed on the intervention devices were significantly more likely to experience postoperative skin changes (i.e.mainly grade 1 pressure ulcers). It is difficult, however, to separate out the role of postoperative care and padding, which was used as a concomitant intervention, either of which may have caused the skin changes (mainly found on buttock and coccyx). Lastly Feuchtinger 2006 terminated the trial comparing an operating theatre table that

included a water-filled warming mattress and a 4-cm thermoactive viscoelastic foam overlay with an operating theatre table with a water-filled warming mattress only. The trial was terminated before the full sample was recruited because more patients in the group receiving the 4-cm thermoactive viscoelastic foam overlay developed pressure ulcers (all were grades 1 to 2).

Implications for practice

For people at high risk of developing pressure ulcers, higher-specification foam mattresses rather than standard hospital foam mattresses should be used, where possible. Organisations should consider the use of selected pressure relief devices for high risk patients in the operating theatre, as this is associated with a reduction in postoperative incidence of pressure ulcers. Medical grade sheepskins are associated with a decrease in pressure ulcer development. The relative merits of higher-tech constant low-pressure and alternating- pressure for prevention are unclear, however, alternating pressure mattresses may be more cost effective than alternating pressure overlays in the UK context. Seat cushions have not been adequately evaluated.

Summary of parts specifically related to surgery

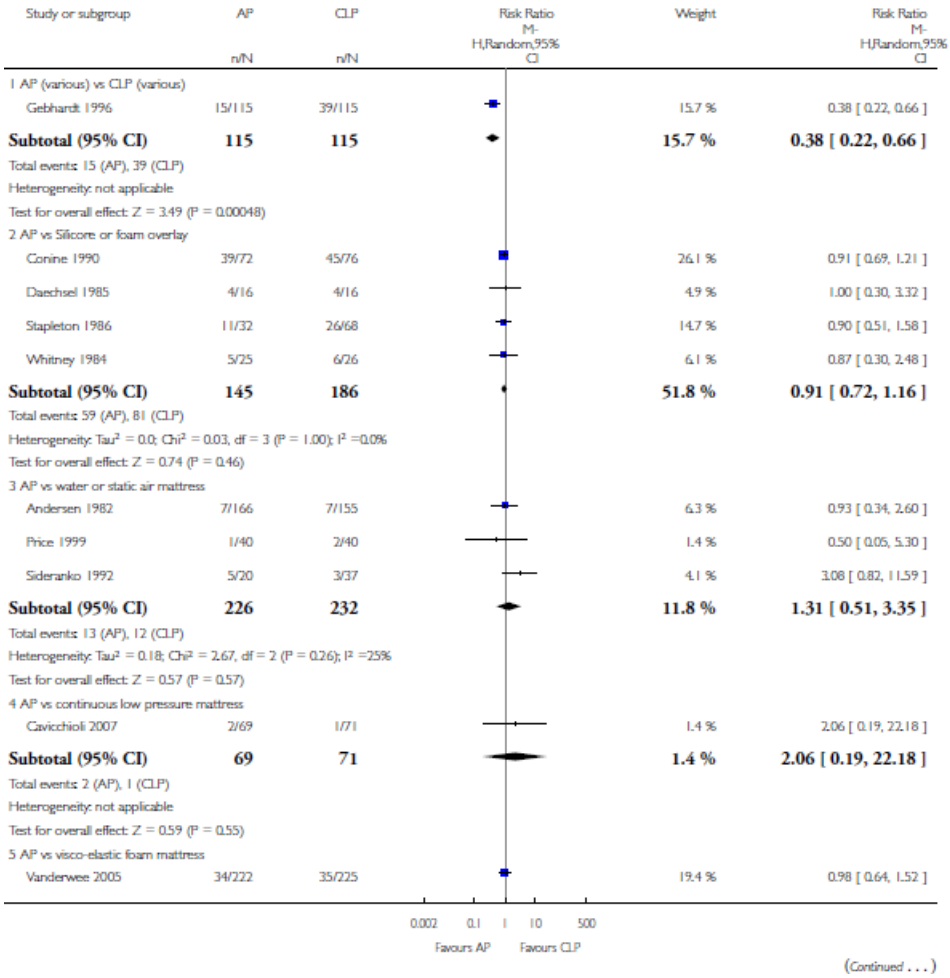
- When compared with standard hospital mattresses, the incidence and severity of pressure ulcers in surgical patients deemed to be high risk were significantly reduced when patients were placed on the cubed foam.
- Constant low pressure devices, such as a water mattress, a foam pad and static air mattresses, and a variety of individually reported no difference in effectiveness for surgical patients compared to different types of alternating-pressure supports (Analysis 6.1).
- There is no benefit of using a series of various combinations of standard, constant low-pressure (Tempur), or an alternating-pressure (Nimbus) support in surgical intensive care patients intra- and post-ICU (Analysis 7.1).
- There is no difference between air-fluidised beds and dry flotation mattress' in postoperative tissue breakdown rates (Analysis 10.1).
- Comparison between kinetic beds and conventional bed showed no beneficial effect of kinetic therapy on incidence of pressure ulcers (Analysis 11.1).
- Viscoelastic polymer pad table overlays compared to no-overlay found a relative reduction in the incidence of postoperative pressure ulcers of 47% associated with the polymer pad (Analysis 12.1).
- A micropulse alternating system (applied both during surgery and postoperatively) with a gel pad during surgery was compared to a standard mattress postoperatively and found to favor the Micropulse system for pressure relief (Analysis 13.1).
- The results of three of the five trials evaluating the use of pressure- relieving overlays on the operating table suggest that these are beneficial in reducing subsequent pressure ulcer incidence in high-risk surgical patients. These three trials were of reasonable or good quality;
- There are tentative indications that four interventions may be harmful. An alternative foam overlay used in the operating theatre suggests that patients were significantly more likely to experience postoperative skin changes (i.e.mainly grade 1 pressure ulcers). It is difficult, however, to separate out the role of postoperative care and padding, which was used as a concomitant intervention, either of which may have caused the skin changes (mainly found on buttock and coccyx). Lastly a trial was terminated comparing an operating theatre table that included a water-filled warming mattress and a 4-cm thermoactive viscoelastic foam overlay with an operating theatre table with a water-filled warming mattress only. The trial was terminated before the full sample was recruited because more patients in the group receiving the 4-cm thermoactive viscoelastic foam overlay developed pressure ulcers (all were grades 1 to 2).

Analysis 6.1. Comparison 6 Alternating-pressure (AP) vs constant low-pressure, Outcome 1 Pressure ulcer incidence.

Review: Support surfaces for pressure ulcer prevention

Comparison: 6 Alternating-pressure (AP) vs constant low-pressure

Outcome: 1 Pressure ulcer incidence



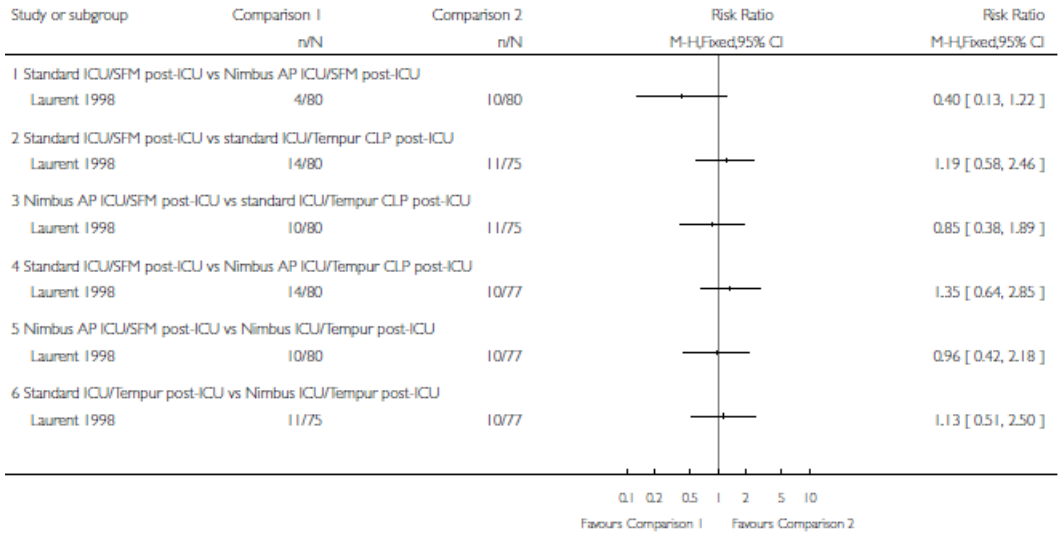
(Continued . . .)

Analysis 7.1. Comparison 7 AP and CLP in ICU/post ICU (factorial design), Outcome 1 Pressure ulcer incidence.

Review: Support surfaces for pressure ulcer prevention

Comparison: 7 AP and CLP in ICU/post ICU (factorial design)

Outcome: 1 Pressure ulcer incidence

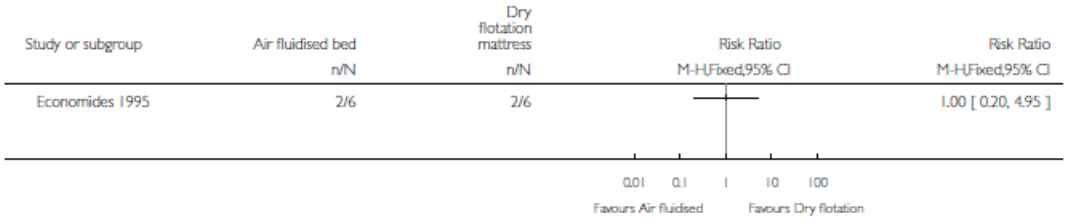


Analysis 10.1. Comparison 10 Air-Fluidised therapy vs dry flotation, Outcome 1 Rate of wound breakdown.

Review: Support surfaces for pressure ulcer prevention

Comparison: 10 Air-Fluidised therapy vs dry flotation

Outcome: 1 Rate of wound breakdown

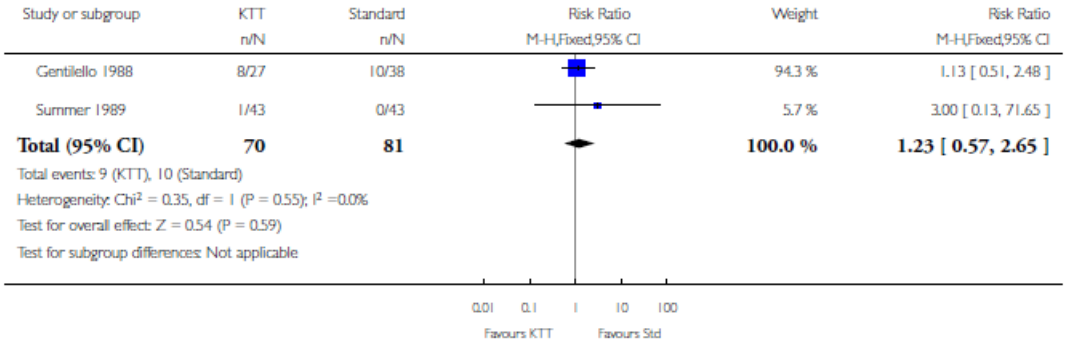


Analysis 11.1. Comparison 11 Kinetic treatment table vs standard care, Outcome 1 Pressure ulcer incidence.

Review: Support surfaces for pressure ulcer prevention

Comparison: 11 Kinetic treatment table vs standard care

Outcome: 1 Pressure ulcer incidence

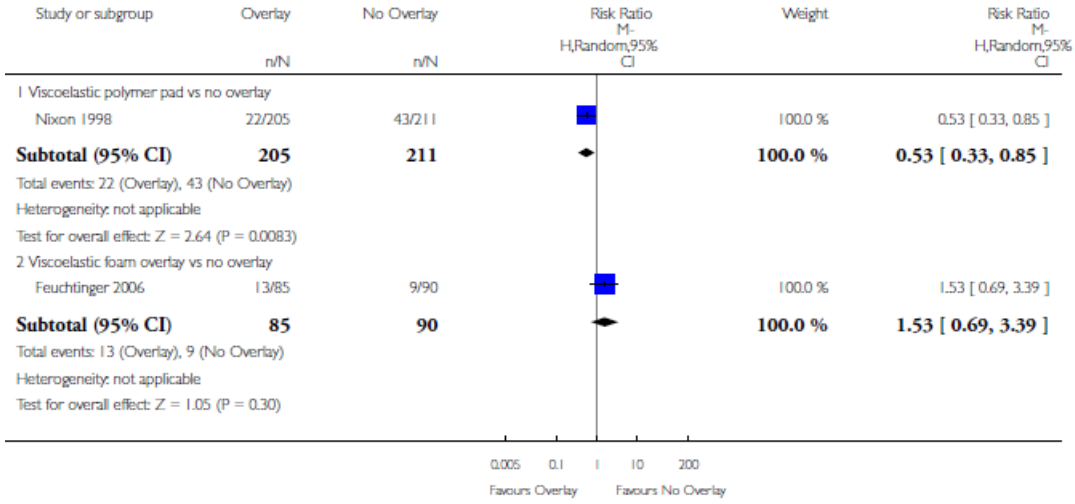


Analysis 12.1. Comparison 12 Operating table overlay vs no overlay, Outcome 1 Pressure ulcer incidence.

Review: Support surfaces for pressure ulcer prevention

Comparison: 12 Operating table overlay vs no overlay

Outcome: 1 Pressure ulcer incidence



Huang et al., 2013.	From the five studies that used a pressure-reducing mattress intra-operatively showed the study mattresses did not provide statistically significant prevention. From the three studies that used pressure-reducing mattress postoperatively, showed the overall effect of the mattresses in preventing PUs was statistically significant. For pressure-reducing mattresses used intra-operatively and postoperatively in the remaining two studies showing prevention was statistically significant (Figure 3). In this meta-analysis, use of pressure-redistribution surfaces postoperatively was found to effectively decrease the incidence of surgery-related Pus compared with standard mattresses. Two systematic reviews demonstrated similar results. In this meta analysis, three included studies

	have investigated the pressure reduction capabilities of support surfaces postoperatively. Hofman et al's prospective, randomized, controlled clinical trial with 44 patients tested the Comfortex DeCube mattress (Comfortex, Winona, MN) against a standard hospital mattress (used in the authors' facility) in 44 patients; at 1 week, 25% of the patients provided the study mattress and 64% of the patients provided the standard mattress had clinically relevant Pus at 2 weeks, the figures were 24% and 68% (P = 0.0067), respectively. Jackson et al10 reported that in 42 postoperative cardiovascular surgery patients, one out of 27 developed a PU (Stage I) while on the air-fluidized therapy bed, compared with 40 ulcers in 25 patients before the intervention (P = 0.0000). In a randomized, controlled trial with 239 postoperative hip fracture patients, Donnelly et al11 reported a significant reduction in the odds of developing a PU using a pressure-redistributing support surface, compared to standard care (eight out of 120 [7%] versus 31 out of 119, [26%], respectively. Although a pressure-reducing mattress used intra-operatively may not have a significant prevention effect, results of additional research merit attention. In a randomized, controlled trial study, Feuchtinger et al found patients placed on an OR table foam overlay experienced slightly more PUs (17.6%) than patients on the standard OR table without the foam overlay (11.1%), adverse results that caused the termination of the RCT. These findings and the results of the current meta-analysis suggest intra-operative use of pressure-reducing mattresses for preventing surgery-related PUs should be implemented with caution. Because the overall result of the current meta-analysis did not meet statistical significance, more well-designed, adequately powered studies are urgently needed. However, in the postoperative subgroup and intra-operative/postoperative subgroup, meta-analysis found a significant reduction in the incidence of PUs when pressure-reducing mattresses were used. In terms of risk assessment, previous meta-analysis showed the Braden Scale was not a good instrument for risk assessment of surgery-related PUs and cannot be used alone for predicting PU risk in surgical patients. A national survey1 in the US of 1,128 patients found the most common types of surgery associated with PU were cardiac procedures (n = 331, 29.3%), general/thoracic procedures (n = 313, 27.7%;), orthopedic procedures (n = 232, 20.6%;), vascular procedures (n = 110, 9.8%;), head and neck (n = 50, 10.0%;), and neurologic (n = 58, 5.2%). The current meta-analysis included four cardiac surgery and two orthopedic surgery patients, persons undergoing high-risk surgical procedures. The national survey1 also found PUs were present in 5.8% of patients whose surgery lasted for 3 to 4 hours; the proportion of patients with intra-operative PUs increased as the surgical time exceeded 3 hours. Schouchoff's review indicated long procedure time also is a risk factor for intra-operative PUs. Another prospective comparative study with 286 adult patients undergoing surgical treatment2 has found low American Society of Anesthesiologists (ASA) or New York Heart Association (NYHA) scores, low food intake, and female gender were risk factors for surgery-related PUs. These considerations, not just Braden Scale score, should help determine patient risk for surgery-related Pus. No publication bias present. One RCT was rated as level 1b evidence with low risk of bias, six RCTs as level 1d evidence with high risk of bias, and the remaining three quasi-randomized control trials were rated level 2b evidence. Overall, a general risk of bias was observed. **Conclusions** A meta-analysis of relevant publications shows postoperative use of pressure- redistribution surfaces can effectively decrease the incidence of surgery-related PUs, while evidence is still not sufficient for routine use of these surfaces intra-operatively. The authors suggest pressure-redistribution surfaces should be used routinely during the postoperative period for high-risk, surgery- related PU patients, and intra-operative use should be more judicious, pending the results of more well-designed, adequately powered, urgently needed studies.

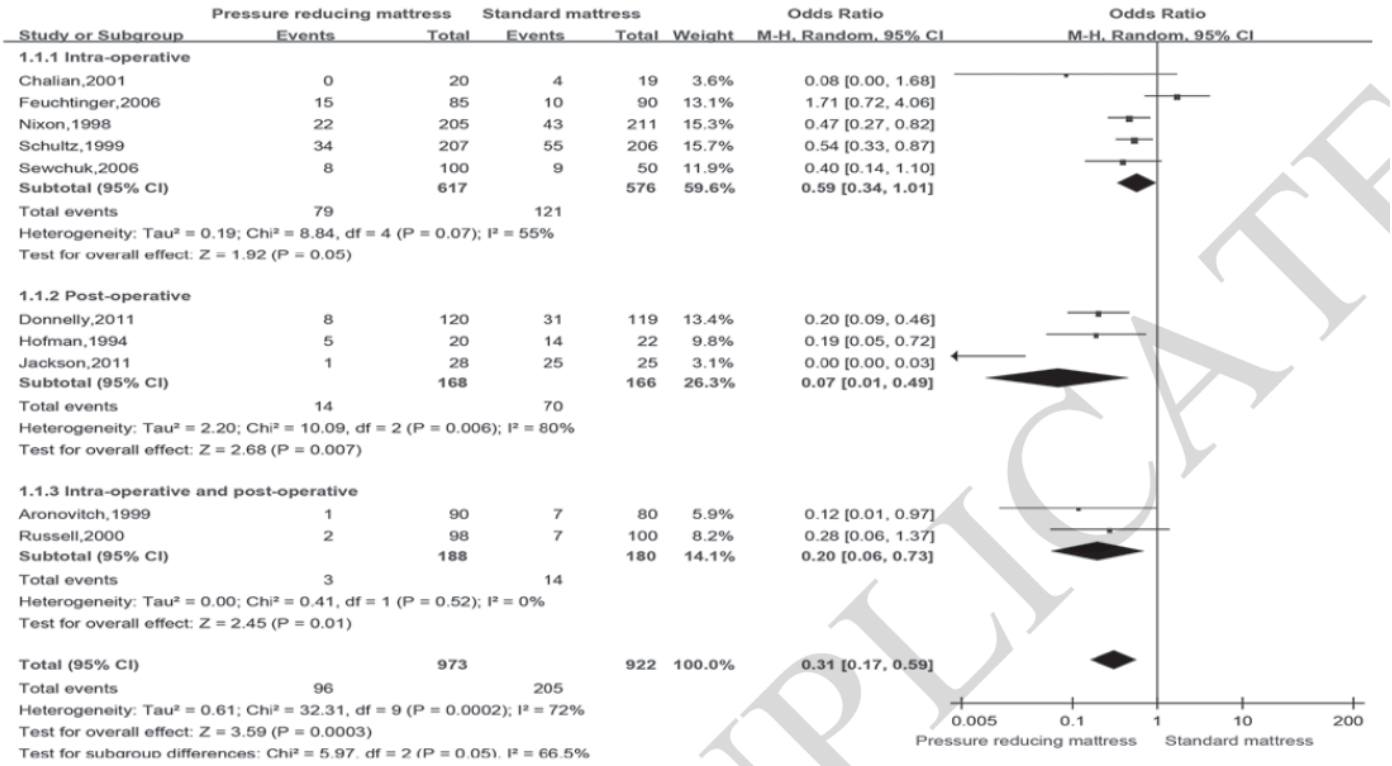


Figure 3. Meta-analysis of pressure-redistribution surfaces in preventing surgery related pressure ulcers.
Square = PU incidence, OR of individual study. Diamond = pooled OR of included studies. An I² >50% indicates heterogeneity.

Moore et al., 2013.	**Dressings** In the Qiuli 2010 study the intervention was a soft silicone, self adherent, bordered foam dressing applied to the integral skin site of pressed bone protuberance. The frequency of dressing changes was not mentioned in the paper. For the control group, massage of the site of bone protuberance was undertaken at each patient turning episode (two- to three-hourly). The duration of massage was not mentioned in the paper. Both groups were nursed on air cushion mattresses and repositioned every two to three hours. In the final study of Kalowes 2012, the intervention was a soft silicone, self-adherent, bordered foam dressing applied to the subjects' sacrum. The dressing was changed every three days, or as needed. No dressing was applied to the skin of the control group participants. Both groups were nursed according to the SKIN bundle (Surface, Keep turning, Incontinence and Nutrition). High risk of bias for both studies. The Qiuli 2010 study had a seven-day follow-up period. The intervention group (n = 26), had a dressing applied at the integral skin site of pressed bone protuberance; pressure ulcer incidence in this group was zero. The control group (n = 26) had no dressing applied, but had massage on the site of bone protuberance; pressure ulcer incidence in this group was 11.5% (n = 3/26). There was no statistically significant difference in pressure ulcer incidence between the two groups (RR 0.14, 95% CI 0.01 to 2.63; P value 0.19) (Figure 6). The Kalowes 2012 study followed up participants while in the intensive care unit, where the mean length of stay was 6.5 days (range 0 to 120 days). The intervention group had a dressing applied to the skin covering the sacral area. The control group had no dressing applied. The incidence of pressure ulcers in the intervention group was 0.5% (n = 1/169), and the incidence in the control group was 4% (n = 7/166). The trial authors reported a statistically significant difference between the groups (P value 0.001), however, RevMan analysis did not replicate this and found no statistical difference between the groups (RR 0.14, 95% CI 0.02 to 1.13; P value 0.06) (Figure 6). When data were combined from these four studies (Han 2011; Kalowes 2012; Nakagami 2007; Qiuli 2010), they showed that dressings applied over bony prominences reduced the pressure ulcer incidence P value to 0.0006; RR 0.21 (95% CI 0.09 to 0.51) (Figure 6). Although the difference was statistically significant, the studies are at high or uncertain risk of bias and firm conclusions cannot be drawn from this analysis. In the Kalowes 2012 trial (335 participants), using a dressing applied to the skin covering the sacral area, yielded no statistically significant difference in the incidence of deep tissue injury compared to the group with no dressing (deep tissue injury: intervention 1/169 (0.5%); placebo 1/166 (0.6%). The remaining six pressure ulcers occurred in the placebo group and were

	classified as: unstageable: 2/166 (1%) and stage 2: 4/166 (2%). When the four dressings trials were combined (Han 2011; Kalowes 2012; Nakagami 2007; Qiuli 2010), dressings applied over bony prominences were found to reduce pressure ulcer incidence however, high or uncertain risk of bias means that firm conclusions cannot be made. **Implications for practice** Pressure ulcers are a relatively common and important complication of hospitalisation and the application of creams or other topical agents is frequently used as an intervention to prevent pressure ulcers from forming. However, there is insufficient evidence from independently funded clinical trials to support or refute the use of topical agents for this purpose. There is also a paucity of evidence from well conducted randomised controlled trials (RCTs) about the effectiveness of dressings to prevent pressure ulcers. Although there was a reduced incidence of pressure ulcers when dressings were used to protect the skin, results were compromised by the low-quality of included trials. These trials contained substantial risk of bias (e.g. inadequate randomisation) and clinical heterogeneity (variations in populations and interventions); consequently, our results should be interpreted as inconclusive.

Figure 6. Forest plot of comparison: Dressing versus no dressing, outcome: 7.1 Pressure ulcer incidence.

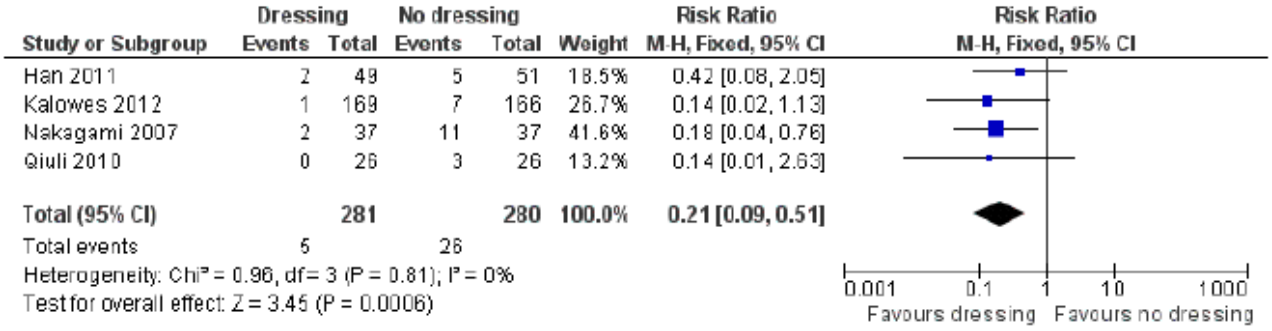


Table 3. Summary of clinical practice guidelines for the prevention pressure injuries pre, during, or post-surgery

NICE, 2014.	<u>Recommendation</u> Consider a high-specification foam theatre mattress or an equivalent pressure redistributing surface for all adults who are undergoing surgery. <u>Operating theatre</u> A viscoelastic polymer pad was clinically beneficial for reducing the incidence of pressure ulcers compared to no overlay. A pressure redistributing (indentation load deflection) operating room foam mattress was not beneficial in comparison to operating room usual care (using padding, gel pads, foam mattresses and ring cushions) for reducing the incidence of all grades of pressure ulcers (grade 1 and above). However grade 2 and above pressure ulcers demonstrated no clinical difference. A multi-cell pulsating dynamic mattress system was more beneficial than the standard mattress (gel pad or standard pad in operating room or a replacement mattress postoperatively or a standard hospital mattress with a 6 inch or 4 inch overlay) for reducing the incidence of all grades of pressure ulcer and, in particular, grade 2 and above. The GDG considered that for people in the operating theatre, a high specification foam theatre mattress should be given as a minimum, as people undergoing surgery were likely to be at risk of developing a pressure ulcer. The group also recognised that in some operating theatres, equivalent pressure redistributing surfaces may be used and that these may provide similar benefits. Therefore a separate recommendation for people undergoing surgery (in the operating theatre) was developed.

National Pressure Ulcer Advisory Panel, 2014.	Recommendations Individuals in the Operating Room 1.Consider additional risk factors specific to individuals undergoing surgery including: •Duration of time immobilized before surgery •Length of surgery •Increased hypotensive episodes during surgery •Low core temperature during surgery •Reduced mobility on day one postoperatively (Strength of Evidence = C; Strength of Recommendation = Strong positive recommendation) 2.Use a high specification reactive or alternating pressure support surface on the operating table for all individuals identified as being at risk of pressure ulcer development. (Strength of Evidence = B; Strength of Recommendation = Weak positive recommendation) 3.Position the individual in such a way as to reduce the risk of pressure ulcer development during surgery. (Strength of Evidence = C; Strength of Recommendation = Strong positive recommendation) 3.1. Use additional support surfaces (e.g., facial pads) to offload pressure points on the face and body while in the prone position. (Strength of evidence = C; Strength of Recommendation = Strong positive recommendation) 3.2. Do not position the individual directly on a medical device unless it cannot be avoided. (Strength of Evidence = C; Strength of Recommendation = Strong positive recommendation) 4.Ensure that the heels are free of the surface of the operating table. (Strength of Evidence = C; Strength of Recommendation = Strong positive recommendation) 4.1. Use heel suspension devices that elevate and offload the heel completely in such a way as to distribute the weight of the leg along the calf without placing pressure on the Achilles tendon. (Strength of Evidence = B; Strength of Recommendation = Strong positive recommendation) 5.Position the knees in slight flexion when offloading the heels. (Strength of Evidence = C; Strength of Recommendation = Weak positive recommendation) 6.Consider pressure redistribution prior to and after surgery. (Strength of Evidence = C; Strength of Recommendation = Strong positive recommendation) 6.1. Place the individual on a high specification reactive or alternating pressure support surface both prior to and after surgery. (Strength of Evidence = C; Strength of Recommendation = Weak positive recommendation) 6.2. Document the individual's position and the anatomical areas under increased interface pressure during surgery. (Strength of Evidence = C; Strength of Recommendation = Strong positive recommendation) 6.3. Position the individual in a different posture preoperatively and postoperatively than the posture adopted during surgery. (Strength of Evidence = C; Strength of Recommendation = Weak positive recommendation)

Conclusions

Currently, it is unknown which pressure ulcer risk assessment scale is best for patients undergoing surgery. Evidence suggests the use of a validated scale in conjunction with clinical judgement is best. A high specification pressure reducing mattress both intra-operatively *and* post-operatively is effective in reducing the incidence of pressure ulcers. The majority of materials are effective however, caution should be exercised regarding the use of a foam overlay or 4-cm thermoactive viscoelastic foam overlay as they may cause more pressure ulcers. Additionally, a five-layer soft silicone bordered dressing for the sacrum, buttock and heel should be used to enhance, but not replace, other pressure ulcer reducing strategies. Consideration on the use of dressings should be given to patients who may be at risk of mechanical stripping the skin when removing the dressing.

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Appendix 1

Question 1a search strategy

Ovid Medline 1946 to Present with Daily Update			
1	exp Pressure Ulcer/	25	(pressure injur$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.
2	exp Skin Ulcer/	26	(pressure damag$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.
3	(decubitus or decubital).mp.	27	(pressure wound$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.
4	(skin adj3 breakdown$).mp.	28	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
5	(bedsore$ or (bed adj1 sore$)).mp.	29	randomized controlled trial.pt.
6	(decubitus adj (ulce$ or sore$)).mp.	30	controlled clinical trial.pt.
7	(pressure$ adj (wound$ or sore$ or ulcer$ or injur$ or damag$)).mp.	31	randomized.ab.
8	1 or 2 or 3 or 4 or 5 or 6 or 7	32	placebo.ab.
9	exp Risk Assessment/	33	drug therapy.fs.
10	((anderson or braden or norton or knoll or waterlow or medley or maelor or arnold or gosnell) adj10 (score$ or scale$ or tool$ or assess$)).mp.	34	randomly.ab.
11	(risk adj2 assess$).mp.	35	trial.ab.
12	((assess$ or predict$) adj10 (tool$ or score$ or scale$)).mp.	36	groups.ab.
13	exp Nursing Assessment/	37	29 or 30 or 31 or 32 or 33 or 34 or 35 or 36
14	((knoll or norton or waterlow) adj modif$).mp.	38	exp animals/ not humans.sh.
15	(birty$ adj para).mp.	39	37 not 38
16	(cubbin adj10 jackson).mp.	40	Meta-Analysis as Topic/
17	(braden adj dupa).mp.	41	meta analy$.tw.
18	(douglas adj ward).mp.	42	Meta-Analysis/
19	(wound$ adj assess$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.	43	(systematic adj (review$1 or overview$1)).tw.
20	(bed sore$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.	44	exp Review Literature as Topic/
21	(decubit$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.	45	40 or 41 or 42 or 43 or 44
22	(pressure ulcer$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.	46	39 or 45
23	(pressure sore$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.	47	8 and 28 and 46
24	(bedsore$ adj10 (tool$ or score$ or scale$ or scoring or instrument$ or equipment$ or device$)).mp.	48	limit 48 to (english language and humans and yr="2013 - Current")

Google
(risk assessment) AND (pressure ulcer or pressure injury) = Google edits at 276 (2013 - Current)

The Cochrane Library
(risk assessment) AND (pressure ulcer or pressure injury) Publication Year from 2013 to 2016

Question 1b search strategy

Ovid Medline 1946 to Present with Daily Update	
1	exp Pressure Ulcer/
2	exp Skin Ulcer/
3	(decubitus or decubital).mp.
4	(skin adj3 breakdown$).mp.
5	(bedsore$ or (bed adj1 sore$)).mp.
6	(decubitus adj (ulce$ or sore$)).mp.
7	(pressure$ adj (wound$ or sore$ or ulcer$ or injur$ or damag$)).mp.
8	1 or 2 or 3 or 4 or 5 or 6 or 7
9	exp General Surgery/
10	surger*.mp.
11	operat*.mp.
12	exp Operating Rooms/
13	exp Preoperative Care/
14	9 or 10 or 11 or 12 or 13
15	exp Secondary Prevention/ or exp Primary Prevention/
16	prevent*.mp.
17	15 or 16
18	8 and 14 and 17
19	limit 18 to (english language and humans and yr="2014 -Current")

Google
(pressure injury or pressure ulcer) AND (surgery or operation) = Google edits at 400 (2013 - Current)

The Cochrane Library
(pressure injury or pressure ulcer) Publication Year from 2013 to 2016