# Pressure ulcer risk during the perioperative period focusing on surgery duration and hypothermia

**The perioperative period for many patients may be the time when they are at highest risk of developing pressure ulcers. The author's literature search identified 24 risk factors which may be contributory factors to pressure ulcer development in the perioperative period. This article focuses on the evidence surrounding surgery duration and hypothermia. Although the findings of the studies reviewed are limited, they highlight the need for preventive interventions to limit these risks. The author concludes that pressure ulcer prevention must be a major concern for staff working in theatres.**

Joan Rogan

**KEY WORDS**
Pressure ulcers
Risk factors
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The perioperative period may be the time for many patients when they are at most risk of developing pressure ulcers. It is unclear from the literature what percentage of pressure ulcers actually begin in the operating theatre. The incidence ranges from 8.5% (Aronovitch, 1999), to 66% (Versluysen, 1986). Although several studies have suggested that the risk of pressure ulceration is greater in older patients, a study by Aronovitch (1999) demonstrated a 9.3% incidence in patients between the ages of 20 and 40 years.

The Department of Health (1993) defines pressure ulcers as areas of skin discolouration or damage which persists after the removal of pressure and which are likely to be due to the effects of pressure on the tissues. This definition would seem to be only partly true in relation to interoperatively-acquired pressure ulcers as there are other causative factors. A literature review produced a large volume of studies which identified a number of risk factors in addition to pressure which may have an impact on the development of pressure ulcers. Kelley (1995) suggests pressure ulcers which begin in the operating room have a more complex aetiology than those in medical patients, due to circulatory and metabolic changes which occur during surgery.

Risk factors identified can be divided into two groups: those which are in existence before surgery such as preoperative comorbidities, advancing age, diabetes, smoking (Papantonio et al, 1994), peripheral vascular disease (Hoshowsky and Schramm, 1994), poor nutritional status, low body weight, low serum albumin and total protein levels (Kemp et al, 1990); and those which occur as a direct result of surgery such as immobility (Schoonhaven et al, 2001), tissue tolerance (Scott, 1998), interface pressure (Nixon et al, 1998), shear, friction (Defloor, 1998), intensity and duration of pressure (Schoonhaven et al, 2001), hypothermia (Scott, 1998), hypotension (Kemp et al, 1990), extra corporal circulation (Lewicki et al, 1997), type of anaesthesia (Bliss and Simini, 1999), surgery type (Aronovitch, 1999) drug therapy (Schoonhaven et al, 2002) and equipment used (Stevens et al, 2004). It is not certain how effective risk assessment tools are as different studies have found them to be both effective and ineffective at predicting risk (Flanagan, 1995; Lewicki et al, 1997; Karadag and Gumuskaya, 2003). Only one risk assessment tool (Waterlow, 1994) includes surgery as a risk factor for pressure ulcers.

This article will review two risk factors associated with surgery — duration of surgery and hypothermia.

## Duration of surgery

In order to cause soft tissue ischaemia, external pressure must exceed capillary pressure to obstruct blood flow. The threshold pressure at which capillaries close is frequently quoted as being 32mmHg (Landis, 1930). However, this is misleading as the study involved young healthy students who would not compare with older or frailer patients. Ek et al (1984) identified pressures as low as 11mmHg being capable of causing capillary closure. In addition, during surgery many patients are placed in anatomically unnatural positions, such as the 'fossa' position where the patient is seated at an 80° angle with the head and shoulder leaning against the operating table, which can put additional pressure on areas that would not normally be accustomed to weight-bearing.

Joan Rogan is Tissue Viability Nurse, Belfast City Hospital

Although high interface pressure is an important factor, the length of time spent on the operating table may also play a significant part. Duration is determined by the length of the surgery. An early study by Kosiak in 1959 identified that low pressures over a long period of time as well as high pressures over a short period of time could lead to pressure damage.

Scott (2005) states a patient lying on a hard surface will get pressure damage sooner than if he or she was lying on a softer surface. The standard theatre table has a thin mattress and a hard surface which means the patient's body weight has to be distributed over this small area, resulting in high interface pressures. In addition, Campbell (1989) demonstrated the practice of placing sheets and drapes under the patient can increase the total amount of pressure by 16mmHg. The operating room table pad was determined to provide a certain amount of pressure reduction. As each layer of cloth or material was added (turn sheets, incontinence pads, warming blankets) each having a lesser pressure-reducing ability, the total pressure reducing ability of the operating room table pad was decreased, thus a higher pressure was obtained creating a negative effect (Campbell, 1989).

The following studies included duration of surgery as a possible risk factor for pressure ulcer development — Campbell (1989); Kemp et al (1990); Hoshowsky and Schramm (1994); Papantonio et al (1994); Grous et al (1997); Lewicki et al (1997); Aronovitch (1999); Schoonhaven et al (2002), and Stevens et al (2004). However, none of the studies assessed duration of surgery as an exclusive factor.

Schoonhaven et al (2002) conducted a clearly defined study involving 208 patients from nine specialties who had surgery which lasted in excess of four hours. The authors choose this duration time to reflect the recommendations of the Panel for the Prediction and Prevention of Pressure Ulcers in Adults (1992) which recommended repositioning patients every two to three hours to prevent pressure ulcer formation. They interpreted this as an indication that the likelihood of developing pressure ulcers in the first three hours of surgery would be small.

The mean average age of the patients was 61 years (range 15–89 years). Duration of surgery ranged from four to more than 9 hours. The patients' skin was assessed preoperatively and every day post-operatively for 14 days. In order to enhance the reliability of the observer's data was not collected by the nurses caring for the patients but by the researcher and three observers. Training had been given to the researchers and inter-rater reliability was assessed as being high. The observers were trained in data collection especially in the observation of pressure ulcers according to a named classification (Haalboom et al, 1997).

In this study group 21% (n=44) of patients developed a total of 70 pressure ulcers within 48 hours of surgery. These varied in severity from grade one (23 patients) to necrosis (two lesions). This study also highlighted the presence of atypical lesions which other authors have acknowledged as arising post-surgery (Vermillion, 1990; Scott, 2005). Thirty-four patients developed lesions which did not fit the description of pressure ulcers as defined in the literature. The authors describe these as being bright red with sharply defined borders which blanched to light pressure. In some patients they caused pain and numbness and despite pressure relief, lasted 13–21 days. These were excluded in the study analysis. A number of patients developed pressures ulcers which were preceded by blanchable erythema. Of these, 11 became stage one lesions and three became stage two lesions. A total of 23 grade two lesions were not preceded by blanchable or stage one ulceration. These results challenge the assumption that non-blanching erythema is a 'safe' observation (Schoonhaven et al, 2002).

While the authors observed an increase in pressure ulcer development corresponding to the duration of surgery, the pattern is not entirely conclusive — 4.8% developed lesions following 5–6 hours surgery; 19% following 6–8 hours surgery and 47.6% following surgery that lasted more than nine hours. The number of patients who developed lesions following 8–9 hours of surgery actually decreased to 9.5%. This would correspond to figures identified in an earlier study by Aronovitch (1999) which reviewed 1,128 patients nationwide, who underwent surgery lasting in excess of three hours.

In this study 11 surgical specialties were represented. The percentage of patients developing ulceration following 3–4 hours surgery was 5.8%; 4–5 hours was 8.9%, 5–6 hours 9.9% and 13.2% in patients undergoing surgery lasting in excess of seven hours. The number of patients developing pressure ulcers who underwent surgery lasting 6–7 hours fell to 7.4%. This outcome may not be statistically significant and could be attributed to other variables within each individual patient. As in the Schoonhaven et al (2002) study, the majority of ulcers were stage one (76%) with 16% being stage two and 8% being ungradeable. There are limitations to this study as the author does not indicate if training had been given and the inter-rater reliability had not been assessed. They also did not mention the grading system used.

In a retrospective study, Stevens et al (2004) identified pressure ulcer risk factors from 382 charts of patients who had specifically undergone varying urological surgery during the previous 10 years. The mean age was 47 years (range 11–73 years). Duration of surgery varied from 30 minutes to 21.55 hours. Fifty-five patients (14.4%) developed pressure ulcers, the majority of which (64%) were grade one. The authors concluded that there was an increased risk of pressure ulcer development associated with duration of surgery and lateral positioning.

Campbell (1989) conducted a small project study involving five patients undergoing vascular surgery. Her main objective was to measure anatomical pressure points at different operative stages. The author measured the patients while in the supine position at three different stages of their inter operative period — pre-anaesthesia, post-anaesthesia and on completion of surgery before being transferred from the operating table. Using a Gaymer® pressure gauge, pressure points were measured on the occipital, scapulae, thoracic spine, sacrum and both heels. Each pressure point was to be measured twice in each of the three phases and an average recorded. However, only the sacral reading was monitored in phase 3 (immediately post-surgery) as the patients could not be turned enough times to obtain the other readings.

Five patients all undergoing vascular surgery below the waist were included in the study, aged 54 years to 72 years with an average age of 51.8 years (m=4; f=1). The author did not identify any comorbidities other than the patients required vascular surgery. The types of surgery are not recorded. The post anaesthesia sacral readings increased on average 27.5% over the pre-anaesthesia sacral readings and increased 30–35% in the post-surgery phase. The difference was determined by the duration of the surgery. If it was less than 2.5 hours the average reading was a 30% increase, if more than 2.5 hours the average increase was 35%. This indicated that the duration of surgery was a definite risk factor. While this is a small study its outcomes are still concerning.

Hoshowsky and Schramm (1994) in a prospective study involving 505 patients assessed a number of variables which included comorbidities, type of operating table surface and duration of surgery. The authors used a points system analysis tool (Hemphill, 1986) which expressed in terms of odds ratios the likelihood of the different variables (along with the patient's general condition) to affect the development of pressure ulceration. The mean age was 47 years (range 13–86 years). Eight surgical types were identified. Duration of surgery was recorded as being less than one hour for 28.7% (n=145) of the subjects, 1–2 hours for 29.9% (n=151), 2–4 hours for 26.5% (n= 134), 4–6 hours for 10.5% (n=53), 6–8 hours for 3.2% (n=16) to greater than eight hours 1.2% (n=6). One author performed preoperative assessments and the other carried out postoperative assessments.

Patients were assessed immediately postoperatively and only 16.8% (n=85) patients developed stage one lesions. Of all the variables assessed, the one single predictor of pressure ulceration was surgical duration — 2.5–4 hours doubled the risk; greater than four hours tripled the risk. The risks were increased in the presence of vascular disease and when the patient was aged over 40 years.

While detailing other variables, the authors identified that duration

of surgery was significantly associated with the development of pressure ulcers. Other studies do not confirm this relationship (Kemp et al, 1990; Papantino et al, 1994; Grous et al, 1997; Lewicki et al, 1997).

Three studies assessed patients specifically undergoing cardiac surgery. In a prospective study by Kemp et al (1990) 125 patients were assessed for a number of risk factors. Mean age was 58 years (range 23–84 years). Fifteen patients (12%) developed a total of 23 pressure ulcers. Six were grade one, six grade two and one grade 3. Grade one ulcers were defined as areas of erythema which did not resolve after 30 minutes. Lewis and Grant (1925) reported that hyperaemic reaction was proportional to the duration of the occlusion, lasting half to three-quarters of the occlusion time. This might indicate that grade one ulcers may have been over-predicted as duration of surgery varied from 45 minutes to 22 hours. The average length of surgery for those patients who developed pressure ulcers was eight hours and several patients (numbers not specified) developed ulcers after two hours. Using discriminate analysis, the authors found length of surgery alone was not a risk factor. However, when combined with advancing age and extra corporeal circulation, it did become a risk factor.

Lewicki et al (1997) studied 337 patients also undergoing cardiac surgery. The mean age was 62 years (range 22–86 years). Of these patients, 4.7% (n=16) had developed a total of 22 pressure ulcers. Thirteen were grade one and five grade two. Four were atypical and were not included in the study. The average duration of surgery for patients developing pressure ulcers was 6.21 hours compared with 6.02 hours for those who did not develop ulceration. The authors therefore concluded that duration of surgery was not a significant risk factor.

Papantonio et al (1994) studied 136 adult patients undergoing cardiac surgery. The mean age of the subjects was 61.9 years with the range not specified. In this study group, 27.2% (n=37) developed ulcers, 43% (n=16) of which remained grade one, while 57% (n=21) progressed to grade two and three. Surgical duration time varied from less than five hours to 16.75 hours. The mean time for those developing ulcers was six hours and the number of lesions did not increase with duration (figures were not specified). The authors concluded that duration on its own was not a risk factor.

A small study by Grous et al (1997) involving 33 patients from five surgical specialties undergoing a surgical duration period in excess of 10 hours did not find duration significant. The average length of surgery was 17 hours with a range of 10–33.5 hours. This study will be discussed later in relation to hypothermia.

The outcomes of these studies are contradictory. The main reason is the populations that were being studied. Differing surgery types, age groups, (some included children) and also the varying interpretation of stage one scores have resulted in the studies being largely incomparable.

## Hypothermia

Hypothermia is a major risk factor associated with significant morbidities. The surgical patient is very much at risk of developing this condition due to the effects of anaesthesia, preoperative fasting, preoperative sedation and exposure (McNeil, 1998). In an attempt to maintain core temperature, the body's natural reaction is to constrict the peripheral blood vessels supplying the skin but consequently, reducing the oxygen, nutritional and waste metabolic activities to the skin. This, combined with unrelieved pressure, may in itself present a risk factor for pressure ulcer development. Various procedures are used to try and maintain normothermia. Warming therapy would appear to be a frequent choice.

Two studies specifically looked at the relationship between hypothermia in surgical patients and pressure ulcer development (Grous et al, 1997; Scott et al, 2001). The studies identified two methods of maintaining normothermia during surgery; a forced air warming system and an under blanket system. Grous et al (1997) suggested that warming blankets or devices placed under the patient inter-operatively stimulated increased blood supply to tissues already compromised by increased pressure. This increased blood supply results in a compromised vasodilatory response that may hasten tissue damage. Campbell (1989) suggested that higher temperatures results in increased metabolic activity which in turn produces increased waste products, thereby adversely affecting peripheral perfusion. A 1°C rise in skin temperature causes a 10% increase in tissue metabolism (Fisher et al, 1978). If the circulation to the tissue is already compromised the further demand for oxygen and nutrients may be unsustainable and lead to increased susceptibility to ischaemic injury (Fisher et al, 1978).

The aim of this descriptive study by Grous et al (1997) was to identify risk factors contributing to pressure ulcer development in patients undergoing prolonged surgery, defined as lasting in excess of 10 hours. The emphasis was on the effects of the warming devices placed beneath patients during surgery. It was a small study of 33 patients, who the authors described as being 'generally healthy'. Their age range was 14–76 years with a mean age of 53.5 years. Preoperative Braden risk assessment scores ranged from 17–23 with a mean of 21.9 indicating low risk for pressure ulcer development. Comorbidities were not determined. Five surgical specialties were involved in the study. The majority of the patients (n=28) were in the supine position. The other positions used were lateral, lithotomy and jack-knife. Devices used in an attempt to maintain normothermia varied from warming blankets to stabilising positioners placed under the patients. Two patients had no devices. Warming blankets were used for 20 patients (67%). Skin was assessed preoperatively and at 48 hours postoperatively by one of the assessment team.

Fifteen patients (45%) developed at least one pressure ulcer. Eight had grade one and seven had grade two in varying locations. Nine were on the buttocks, two on the sacrum, one on the scapula, one on the anterior chest wall, one on the right ear and one was occipital. The authors used the National Pressure Ulcer Advisory Panel (1989) grading, but also stated that the lesions had the appearance of 'surgical burns'. All ulcers were noted within 48 hours of surgery. Of the 15 patients who developed pressure ulcers 75% had used warming blankets. The authors did not identify any other significant factors in predicting pressure ulcer formation. They felt the negative outcomes produced by the warming blankets necessitated the discontinuation of the trial, advocating that warming blankets should not be used.

A number of questions have arisen about the validity of this study. First, the numbers involved in the study were small (33 patients). While the patients were said to be healthy it would appear that a significant number had a diagnosis of cancer given that the main surgery type was related to head and neck cancer (67%). The duration of surgery time (the longest was 33.5 hours) would indicate that very major interventions were involved. It is also not clear from the study if the same warming device was used uniformly. While the patient's skin was assessed both pre- and postoperatively by one of the assessors, there is nothing to identify whether it was the same assessor and what their knowledge base, inter-reliability skills were, nor if they were blinded. There is no record to state what type of mattress the patient was nursed on postoperatively and if the patient was able to be repositioned. It is possible that some of these lesions could have developed during this period and therefore not have been directly as a result of the warming blanket. The location of some of the lesions in relation to the positions used do not totally correlate. One was on the anterior chest wall which may suggest that it could have been caused by an ECG lead. One lesion was on the ear and the other was occipital, and while these are most likely due to pressure, they are not in an area that would be affected by a warming blanket. The authors' recommendation was that warming blankets should not be used during surgery. Given the potential morbidity associated with hypothermia, this statement should be rephrased so that other methods could be considered.

The aim of a prospective, randomised control trial by Scott et al in 2001 was to determine if there was a correlation between hypothermia and pressure ulcer development. The study involved 324 patients (41–89 years) who were randomised into two groups. Group one received the standard perioperative care and group two the standard perioperative care plus a warming therapy system as well as their IV fluids being warmed. Both groups had similar characteristics. Based on the findings of previous authors, the researchers decided not to use an under blanket, but chose a forced air over-blanket. All patients were scheduled to undergo major surgery, defined as necessitating at least a five-day postoperative stay in hospital. Five surgical specialties were identified. Comorbidities relating to peripheral vascular disease, diabetes, heart disease and smoking were identified, as was body mass index. Duration of surgery varied from 45–365 minutes (6 hours). Core temperature was measured by tympanic thermometers, described by the authors as being the most accurate. Patients were followed-up for five days postoperatively and their skin assessed by the principle researcher, who was blinded to the treatment group, on days one, three and five. The study omitted to record if any other pressure-relieving equipment had been used.

The study found the incidence of pressure ulcers almost halved through the use of warming therapy. In total 8% (n=26) of the study group developed pressure ulcers; 65.4% (n=17) in the standard group, 34.6% (n=9) in the warming group. Ulcers were not graded, but defined as persistent (lasting in excess of 24 hours) non-blanching erythema or a break in the skin. The ulcers were positioned on the sacrum (n=12), heel (n=9) and buttock (n=5). The researchers found a significant correlation between small body size (based on BMI) and the lowest core temperature suggesting that body fat had an impact on the maintenance of body temperature. Significantly a greater number of patients receiving general anaesthesia (10.4%; n=19) developed pressure ulcers compared with those receiving regional anaesthesia (4.4%; n=6). In general, older patients were more likely to develop pressure ulcers, but this was not statistically significant (p=0.27). The duration of surgery was not found to be significant. This was a clearly designed study with significant outcomes not only in favour of using this method of warming therapy during surgery but also showed its ability to reduce the incidence of pressure ulcers.

## Summary

Campbell (1989) describes the interoperative period for many patients, as being the time that they are at the highest risk of developing pressure ulcers during their entire hospital stay. The number of risk factors identified would confirm that statement. Unfortunately the author could not identify a consensus on the predictive risks for inter-operative pressure ulcer development from the studies reviewed. This is because the various researchers have used different study designs mostly concentrating on a number of different variables rather than one specific risk factor. They have also used different pressure ulcer classifications and incomparable patient groups. While the methodology in some studies has been very precise, it is less so in others. The quality and experience of those making the skin assessments in some studies have raised questions to the validity of the recorded outcomes. This has resulted in inconclusive results with no preoperative or interoperative factors being indisputably linked to pressure ulcer formation during surgery.

The one agreement is pressure ulcer development in the perioperative period is a serious problem which

## Key Points

- Many patients are at greater risk of developing pressure ulcers in the perioperative period.
- There are many factors that are implicated in the increased risk including duration of surgery and hypothermia.
- The author could not identify a consensus on the predictive risks for inter-operative pressure ulcer development from the studies reviewed. Despite this, the evidence highlights that surgery puts patients at a very high risk of pressure ulcer development. It is essential that preventive interventions are made to limit these risks.

needs to be addressed. All patients irrespective of their age should be considered to be at risk of pressure ulcer development during this time. Within Europe and the USA there are dedicated pressure ulcer groups, (European Pressure Ulcer Advisory Panel and the National Pressure Ulcer Advisory Panel). Perhaps these organisations should give clear guidelines on how future research studies should be approached in order to gain clear outcomes that can be reflected in subsequent evidence-based practice. WUK

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