

REVIEW ARTICLE

Pressure ulcers in cardiac surgery: Few clinical studies, difficult risk assessment, and profound clinical implications

Camilla Chello¹ | Mario Lusini² | Davide Schilirò² | Salvatore Matteo Greco² | Raffaele Barbato² | Antonio Nenna²

¹Department of Dermatology, University of Rome "La Sapienza", Rome, Italy

²Department of Cardiovascular Surgery, University "Campus Bio-Medico di Roma", Rome, Italy

Correspondence

Antonio Nenna, MD, Department of Cardiovascular Surgery, University "Campus Bio-Medico di Roma", Via Alvaro del Portillo 200, 00128 Rome, Italy.

Email: a.nenna@unicampus.it

Pressure ulcers (PUs) are a common complication after cardiac surgery, with almost one third of patients suffering from PUs during hospitalisation. Because of the burden that PUs exert on both the patients and the health care system, prevention is of utmost importance. The first step in successful prevention, however, includes the identification of the main features that render patients prone to PU development. Cardiac surgery population is not adequately addressed in current clinical trials and studies. Few studies focused specifically on cardiac surgery patients, but the majority included cardiac surgery patients within a heterogeneous population of acute or critical care patients. Therefore, additional research is warranted to understand the unique risk profile of patients undergoing cardiac surgery. Intraoperative risk factors that affect tissue tolerance have not been thoroughly investigated but are likely to play an important role, which might explain the epidemiology of a PU. Further research is also needed to better comprehend the risk of PUs among cardiac surgery patients and to design effective and tailored preventative measures with the help of newer tools for risk assessment.

KEYWORDS

cardiac surgery, intensive care unit, pressure ulcers

1 | INTRODUCTION

Pressure ulcers (PUs) are a common complication after cardiac surgery, with a mean reported incidence of 25% to 30% during hospitalisation.¹ A systematic review pooled 17 studies with 5451 patients and found that the incidence of PUs in surgical patients in the last 5 years was 15.0%, and the most common types of surgery-related PUs occurred after cardiac procedures (29.3%).² The painful clinical presentation might be associated with serious adverse complications such as infection, sepsis, or severe disability, and if untreated, PUs can lead to death.¹ From an economic point of view, PUs tend to increase in-hospital length of stay by up to 10 to 15 days and may require intensive treatment, which can exceed \$50,000.³ Because of the burden PUs exert on both the patients and the health care system, prevention plays a pivotal role. The first step in successful prevention, however,

includes the identification of the main features that render patients prone to PU development. Close to the cardiac surgery scenario, a recent article showed that infants admitted in intensive care units suffered from PU, and the risk increases with the length of stay and use of non-invasive mechanical ventilation.⁴ Considering that this article has led to the resurface of the "PU problem" in the recent literature, it appears important to provide an immediate outlook about this phenomenon, even in the unique setting of adult cardiac surgery, and suggest new avenues for future research.

2 | MECHANISMS OF DISEASE

A plethora of studies have examined the factors related to PU onset and progression, but the relatively high PU incidence among cardiac surgery patients suggests that typical

PU prevention methods are not sufficient for this specific population.^{1,3} However, this topic appears to be slightly neglected by the recent literature, and very few recent studies pointed out the mechanisms of PUs in the setting of cardiac surgery.

PU pathogenesis is mediated by two players: pressure mediated by compressive and shearing forces, reducing blood supply, and tissue's tolerance for pressure, which might be reduced in many clinical conditions. Tissue tolerance is an intermediate variable comprised of an individual's tolerance for pressure (based on factors such as age and nutritional status) and an individual's tolerance for oxygen (based on oxygen supply and oxygen needs). The interplay between pressure and tissue's tolerance mediates tissue damage and may result in the development of PUs (Table 1).⁵⁻⁷

3 | CLASSIFICATION AND DETECTION

The most common classification scale used is adapted from the National Pressure Ulcer Advisory Panel and redefined in 2007⁸:

- *Stage I, non-blanchable redness.* A PU is an observable pressure-related alteration of intact skin whose indicators, compared with an adjacent or opposite area on the body, may include changes in one or more of the following: skin temperature (ie, warmth, coolness), tissue consistency (egg, firm, boggy feel), and sensation (ie, pain, itching). The ulcer appears as a defined area of persistent redness in lightly pigmented skin, whereas in darker skin tones, the ulcer may appear with persistent red, blue, or purple hues.
- *Stage II, partial-thickness skin loss.* Partial-thickness skin loss involving the epidermis, dermis, or both. The ulcer is superficial and presents clinically as an abrasion, blister, or shallow crater.
- *Stage III, full-thickness skin loss.* Full-thickness skin loss involves damage to, or necrosis of, subcutaneous tissue that may extend down to, but not through, underlying

Key Messages

- pressure ulcers (PUs) are a common complication after cardiac surgery, with almost one third of patients suffering from PUs during hospitalisation; because of the burden that PUs exert on both the patients and the health care system, prevention is of utmost importance
- cardiac surgery population is not adequately addressed in current clinical trials and studies; few studies focused specifically on cardiac surgery patients, but the majority included cardiac surgery patients within a heterogeneous population of acute or critical care patients
- prevention measures should be aimed at supporting tissue tolerance for pressure and tissue tolerance for oxygen through sensitive temperature management during surgical procedures, sensitive blood pressure management, normalisation of albumin level, attention to patient's age and comorbidities, pressure-relieving devices on the operative table, and early mobilisation.

fascia. The ulcer presents clinically as a deep crater with or without undermining of adjacent tissue.

- *Stage IV, full-thickness tissue loss.* Full-thickness skin loss with extensive destruction; tissue necrosis; or damage to muscle, bone, or supporting structures (ie, tendon, joint, capsule). Undermining and sinus tracts may also be associated with stage IV PUs.

In addition, the number of ulcers and their anatomical location (sacrum, coccyx, heels, ischial tuberosities, or other sites) should be indicated. This helps in the choice of the most appropriate treatment (topical dressings, negative pressure wound therapy, or others).

4 | RISK ASSESSMENT

Risk assessment is the first step for the prevention of PUs, but the most widely used Braden Scale was found to have low predictive validity for PUs, with an estimated sensitivity of 0.42, a specificity of 0.84, and an area under the Receiver Operating Characteristic (ROC) curve of 0.69.⁹ Therefore, other scales were investigated for surgical patients, but within a cardiac surgery population, sensitivity and specificity at all scales were not satisfactory.¹⁰

A recent study evaluated a nomogram score for predicting PUs in cardiac surgery patients¹¹ using a retrospective cohort of 149 patients; 37 patients developed PUs (24.8%), generally rated Stage 1. In a multivariate logistic regression model with all the risk factors, authors found that disease category, weight, surgery duration, and perioperative corticosteroids administration were independent risk factors for

TABLE 1 Common risk factors for pressure ulcers

Risk factors	Physical factors
Age	Pressure (compressive) forces
Acuity of illness	Shearing forces
Immobility	
Moisture settings	
Diabetes mellitus	
Vascular disease	
Nutritional status	
Malignant tumour	
General skin problems	
Smoking	

PU, while other variables were not (gender, smoke status, diabetes, perioperative albumin levels, cardiopulmonary bypass (CPB) duration, postoperative mechanical ventilation duration, vasoactive agents intraoperatively, and vasoactive agents postoperatively). Considering disease category, weight, surgery duration, and perioperative corticosteroids use, a nomogram model for PU prediction has been suggested, considering corticosteroids use, surgery duration, weight, and disease category. Authors concluded that when the total score is more than 12, the cardiovascular surgery patient should be considered to be at high risk. However, the patients were recruited from a single centre, and this study also included patients undergoing major vascular surgery with CPB (eg, thoracoabdominal aneurysm surgery); therefore, this nomogram should be tested for its validity and applicability in other centres.

5 | CARDIAC SURGERY: THE INTRINSIC PROBLEM

Before, during, and after surgical procedure, patients are exposed to a variety of factors that account for the higher incidence of PUs in this setting compared with other surgical populations. Considering a mean procedural time of at least 3 to 4 hours, which includes patient's preparation for the operation (intubation, central venous catheter placement, etc.), patients remain on the operating room table for extended periods of time, with prolonged exposure to pressure. In the meantime, tissue tolerance to hypoxia is reduced because of vascular disease, vasoconstrictions/vasoconstrictors, and hypothermia.

Intraoperative hypotension occurs frequently because of CPB and significant blood loss. The head of the bed should be elevated for postoperative mechanical ventilation, which increases friction; some patients are also not repositioned for hours or even days when using balloon pumps or other devices. Therefore, in cardiac surgery patients, PUs can easily, but it remains difficult to find one specific risk factor. Based on the current evidence,^{12–23} Rao et al²⁴ identified the most common risk factors associated with PU development in cardiac surgery (Table 2).

However, length of surgery *in se* is not necessarily associated with PUs. It is acknowledged that PU incidence increased gradually with the extension of the length of surgery, but when surgery extended to 360 to 600 minutes, PU incidence dropped unexpectedly (11%).⁸ Besides the caveat of the small sample size of this study when evaluating longer procedures, also observed in Aronovitch's national survey, PU incidence declined when length of surgery was 9, 10, and 11 hours, with an incidence of 3.0%, 0.0%, and 0.0%, respectively.²⁵ A similar pathway has been observed by Schoonhoven et al²⁶ Further studies are needed to determine the mechanism.

TABLE 2 Cardiac surgery-specific factors for pressure ulcers

Preoperative risk factors
Previous pressure ulcer (PU)
Skin problems in areas at risk for PU
Haemodialysis
Creatinine > 3 mg/dL
Poor mobility
Faecal incontinence
Vascular disease
Anaemia
Low body mass index
Intraoperative risk factors
Total number of surgeries
Total time in operating room
Postoperative risk factors
ICU length of stay > 3 days
Use of vasopressors
Mechanical ventilation
Application of sedative drugs
Postoperative steroid use
Postoperative Braden scale score

In cardiac surgery settings, mechanisms leading to PUs can be grouped into three categories¹: compressive force and shearing force (influenced by operating room time, frequency of repositioning, or intra-aortic balloon pump placement), tissue tolerance for pressure (influenced by age, nutritional status, and corticosteroid use), and tissue tolerance for oxygen (influenced by body temperature, haemoglobin level, vasoactive drugs, and comorbidities).

6 | RECOMMENDATION FOR CLINICAL PRACTICE

Although studies regarding risk indicators for PU development in the cardiac surgery population are few, some recommendations have been proposed.^{1,10} Prevention measures should be aimed at supporting tissue tolerance for pressure and tissue tolerance for oxygen through sensitive temperature management during surgery procedure (minimise hypothermia), sensitive blood pressure management (avoid prolonged hypotension and prolonged use of vasopressors), normalisation of albumin level (with diuretics or supplementation), attention to patient's age and comorbidities (diabetes, chronic kidney disease, cerebrovascular disease), pressure-relieving devices on the operative table, and early mobilisation.

7 | LIMITATIONS OF CURRENT LITERATURE

The cardiac surgery population is not adequately addressed in current clinical trials and studies. Few studies focused

specifically on cardiac surgery patients, but the majority included cardiac surgery patients within a heterogeneous population of acute or critical care patients.

In addition, there is a lack of consensus about suspected deep tissue injuries (SDTIs), which are defined as a purple or maroon localised area of discoloured intact skin because of damage of the underlying soft tissue.²⁴ Beginning as a blister, they evolve to a thin eschar, which then progresses, exposing inner layers of tissue. Very few studies specifically evaluated SDTI, which might have also a distinct pathogenesis, related to ischaemia-reperfusion damage rather than pressure.²⁷

8 | PERSPECTIVES

Additional research is warranted to understand the unique risk profile of patients undergoing cardiac surgery. Current studies do not completely clarify why cardiac surgery patients are prone to develop PUs. It is possible to hypothesise that cardiac surgery itself puts patients at risk. Therefore, future research should focus on unique factors related to cardiac surgery. For example, the use of vasopressors, intraoperative CPB time, and body temperature affects tissue tolerance for oxygen and may contribute to PU development. In addition, further research is necessary to scientifically evaluate PU occurrence and external factors, such as time on the odds ratio (OR) table, differences in temperature and blood pressure management, and differences in mobility activities after surgery considering that most of the recent literature is derived from retrospective analysis and cohort studies.

9 | CONCLUSION

Several factors have been identified that contribute to the high incidence of PUs in cardiac surgery patients. In contrast, evidence of unique factors strongly associated with cardiac surgery is lacking. Intraoperative risk factors that affect tissue tolerance have not been thoroughly investigated but are likely to play an important role, which might explain the epidemiology of a PU. Further research is also needed to better comprehend the risk of PUs among cardiac surgery patients and to design effective and tailored preventative measures with the help of newer tools for risk assessment.

REFERENCES

- Feuchtinger J, Halfens RJ, Dassen T. Pressure ulcer risk factors in cardiac surgery: a review of the research literature. *Heart Lung*. 2005;34:375-385.
- Chen HL, Chen XY, Wu J. The incidence of pressure ulcers in surgical patients of the last 5 years: a systematic review. *Wounds*. 2012;24:234-241.
- Brindle CT, Wegelin JA. Prophylactic dressing application to reduce pressure ulcer formation in cardiac surgery patients. *J Wound Ostomy Continence Nurs*. 2012;39:133-142.
- García-Molina P, Balaguer-Lopez E, García-Fernández FP, Ferrera-Fernández MLA, Blasco JM, Verdu J. Pressure ulcers' incidence, preventive measures, and risk factors in neonatal intensive care and intermediate care units. *Int Wound J*. 2018;15:571-579.
- Defloor T. The risk of pressure sores: a conceptual scheme. *J Clin Nurs*. 1999;8:206-216.
- Benoit R, Mion L. Risk factors for pressure ulcer development in critically ill patients: a conceptual model to guide research. *Res Nurs Health*. 2012;35:340-362.
- Bergstrom N, Braden BJ, Laguzza A, Holman V. The Braden scale for predicting pressure sore risk. *Nurs Res*. 1987;36:205-210.
- Shen WQ, Chen HL, Xu YH, Zhang Q, Wu J. The relationship between length of surgery and the incidence of pressure ulcers in cardiovascular surgical patients: a retrospective study. *Adv Skin Wound Care*. 2015;28:444-450.
- He W, Liu P, Chen HL. The Braden scale cannot be used alone for assessing pressure ulcer risk in surgical patients: a meta-analysis. *Ostomy Wound Manage*. 2012;58:34-40.
- Feuchtinger J, Halfens R, Dassen T. Pressure ulcer risk assessment immediately after cardiac surgery—does it make a difference? A comparison of three pressure ulcer risk assessment instruments within a cardiac surgery population. *Nurs Crit Care*. 2007;12:42-49.
- Lu CX, Chen HL, Shen WQ, Feng LP. A new nomogram score for predicting surgery-related pressure ulcers in cardiovascular surgical patients. *Int Wound J*. 2017;14:226-232.
- Kemp MG, Keithley JK, Smith DW, Morreale B. Factors that contribute to pressure sores in surgical patients. *Res Nurs Health*. 1990;13:293-301.
- Papantonio CT, Wallop JM, Kolodner KB. Sacral ulcers following cardiac surgery: incidence and risks. *Adv Wound Care*. 1994;7:24-36.
- Lewicki LJ, Mion L, Splane KG, Samstag D, Secic M. Patient risk factors for pressure ulcers during cardiac surgery. *AORN J*. 1997;65:933-942.
- Stordeur S, Laurent S, D'Hoore W. The importance of repeated risk assessment for pressure sores in cardiovascular surgery. *J Cardiovasc Surg (Torino)*. 1998;39:343-349.
- Theaker C, Mannan M, Ives N, Soni N. Risk factors for pressure sores in the critically ill. *Anaesthesia*. 2000;55:221-224.
- Pokorny ME, Koldjeski D, Swanson M. Skin care intervention for patients having cardiac surgery. *Am J Crit Care*. 2003;12:535-544.
- Frankel H, Sperry J, Kaplan L. Risk factors for pressure ulcer development in a best practice surgical intensive care unit. *Am Surg*. 2007;73:1215-1217.
- Nonnemacher M, Stausberg J, Bartoszek G, Lottko B, Neuhaeuser M, Maier I. Predicting pressure ulcer risk: a multifactorial approach to assess risk factors in a large university hospital population. *J Clin Nurs*. 2009;18:99-107.
- Nijs N, Toppets A, Defloor T, Bernaerts K, Milisen K, Van Den Berghe G. Incidence and risk factors for pressure ulcers in the intensive care unit. *J Clin Nurs*. 2009;18:1258-1266.
- Cox J. Predictors of pressure ulcers in adult critical care patients. *Am J Crit Care*. 2011;20:364-375.
- Fred C, Ford S, Wagner D, Vanbrackle L. Intraoperatively acquired pressure ulcers and perioperative normothermia: a look at relationships. *AORN J*. 2012;96:251-260.
- Tschannen D, Bates O, Talsma A, Guo Y. Patient-specific and surgical characteristics in the development of pressure ulcers. *Am J Crit Care*. 2012;21:116-125.
- Rao AD, Preston AM, Strauss R, Stamm R, Zalman DC. Risk factors associated with pressure ulcer formation in critically ill cardiac surgery patients: a systematic review. *J Wound Ostomy Continence Nurs*. 2016;43:242-247.
- Aronovitch SA. Intraoperatively acquired pressure ulcer prevalence: a national study. *J Wound Ostomy Continence Nurs*. 1999;26:130-136.
- Schoonhoven L, Defloor T, van der Tweel I, Buskens E, Grypdonck MH. Risk indicators for pressure ulcers during surgery. *Appl Nurs Res*. 2002;15:163-173.
- Smart H. Deep tissue injury: what is it really? *Adv Skin Wound Care*. 2013;26:56-58.

How to cite this article: Chello C, Lusini M, Schilirò D, Greco SM, Barbato R, Nenna A. Pressure ulcers in cardiac surgery: Few clinical studies, difficult risk assessment, and profound clinical implications. *Int Wound J*. 2018;1–4. <https://doi.org/10.1111/iwj.12994>