Is there a place for surgical site assessment using new imaging modalities during routine clinical care? A review of dressing use and changes from an online survey

KEY WORDS

- Imaging
- Infrared
- Dressing change
- Dressings, treatment
- Pay grade
- Regime
- Sonography
- Surgical wound

PASANG TAMANG
Postgraduate Researcher School of Human and Health Sciences, University of Huddersfield, UK.

CHARMAINE CHILDS
PhD, Professor of Clinical Science, College of Health, Wellbeing and Life Sciences, Sheffield Hallam University, UK

JOHN STEPHENSON,
PhD, Senior Lecturer in Biomedical Statistics, Institute of Skin Integrity and Infection Prevention, School of Human and Health Sciences, University of Huddersfield

KAREN OUSEY,
PhD, Professor of Skin Integrity, Director for the Institute of Skin Integrity and Infection Prevention - University of Huddersfield Department of Nursing

Abstract: The care and management of surgical incisional wounds continues to attract both interest and concern, due to continued high rates of surgical site infection (SSI) and morbidity. Novel approaches to objective wound assessment using non-invasive imaging modalities show promise in providing independent, objective wound assessment but only with the proviso that the wound is visible and can be 'seen' by the imaging detector. **Methods**: An online semi-structured questionnaire was distributed via Survey Monkey to tissue viability nurses. Data was summarised descriptively, with responses relating to participant demographics and use of wound dressings tabulated. Key variables were also cross tabulated to investigate possible associations between variables. An economic analysis was conducted to estimate average weekly costs associated with changing and applying dressings, including both staff and equipment costs. **Conclusion**: The largest type of dressing products currently in use were non-adherent. Dressing changes took place approximately twice per week: more frequently if wounds were assessed/diagnosed as infected. The majority of wound assessment and dressing changes were undertaken by band 5, 6 or 7 nurses. There is a potential role for non-invasive infrared thermography to stratify risk of later SSI based upon the temperature distribution across wound site and adjacent skin territories. Early and objective interventions for early wound infection can reduce hospital inpatient stay, community visits, antimicrobial usage, patient morbidity and healthcare costs related to wound infection.

The care and management of surgical incisional wounds continues to attract both interest and concern among researchers, clinical and national wound care programmes because of the continued high rates of surgical site infection (SSI) and morbidity (Public Health England [PHE], 2020). SSI persists as a potentially avoidable postoperative complication, affecting over 500,000 surgical patients in the US every year (Najjar et al, 2015). In the UK, national surveillance programmes provide estimates of SSI incidence, with the highest reported risk being large bowel surgery (8.3%), implicating high bacterial load at this surgical site (PHE, 2020). However, not all surgical procedures are included in the national surveillance programme (Troughton et al, 2018). One example is Caesarean section, a surgical procedure neither in a mandatory nor voluntary surgical category under the Surgical Site Infection Surveillance Service (SSISS) programme for England (PHE, 2021). Research publications for this clean/clean-contaminated surgery show that for highest risk groups,obese and morbidly obese women, proportions in excess of 20% (Childs et al, 2019) and 50% (Yeeles et al, 2014) respectively have been reported. Each SSI episode represents an additional healthcare treatment cost (Wloch et al, 2020).

Central to the wound care budget is appropriate selection (and cost) of dressing products and frequency of dressing changes. While a range of standard and advanced dressing materials and therapies exist, there is also a wide variety of protocols for dressing changes. Anecdotal evidence suggests that decisions around timing and frequency of dressing changes are routine, habitual and ritualistic (Berg et al, 2019; Davies et al, 2019) with the potential for unnecessary disturbance of wound healing if too frequent Blackburn et al (2018). Conversely, while the concept of undisturbed wound healing (Stephen-Haynes 2015) may be beneficial from a wound healing and cost reduction perspective, it does present a real barrier to the polar opposite view in support of regular visual assessment of the wound; an essential activity for monitoring of healing progression (National Wound Care Strategy Programme [NWCSP], 2015). Recommendations for digital imaging are to become a part of standard practice (NWCSP, 2015). Wound photographs (Langemo et al, 2006; Estocado and Black, 2019) can be uploaded to the patient's clinical record as a useful adjunct to wound assessment tools and written documentation. Objective imaging assessment is especially important, as recent evidence (Childs et al, 2019) reveals a lack of agreement in wound assessment between even the most experienced of clinicians and wound care practitioners. Furthermore, in addition to digital photography, opportunities have arisen with advances in technology for the application of non-invasive imaging modalities (Madajewski et al, 2012; Barrett et al, 2016; Childs et al, 2019) to provide independent, objective wound assessment options but only with the proviso that the wound is visible and can be 'seen' by the imaging detector.

A major obstacle to regular wound photography and/or wound imaging is the presence of occlusive dressings, especially those which remain *in situ* during the first week after surgery. As a result, any change in the state of wound edges and pre-incision tissue during this time are not visible to the healthcare professional. For patients with surgical wounds treated using advanced wound therapies, 'designed' for longer term use, the cost-benefit of a dressing change, balanced against the need for visual inspection, should be taken into consideration before wound dressings are taken down. For example, Negative Pressure Wound Therapy (NPWT) for example, PICO (Smith and Nephew, Hull UK), is now promoted for SSI prophylaxis in the National Health Service (NHS) for closed surgical incisions (NICE, 2018). This type of costly advanced wound therapy, recommended by the manufacturer to remain undisturbed from the time of primary wound closure until removal 5–7 days later, still lacks clear evidence of benefit for SSI reduction (Li et al, 2019; Webster et al, 2019; Norman et al, 2020) even in high risk (obese) women after caesarean section (Wihbey et al, 2018; Gillespie et al, 2021). By obscuring the wound during the first week after surgery, subtle changes in the wound will inevitably be missed; as will opportunities for the use and potential advantages of new and emerging imaging technologies in wound care.

Aim

The overall aim of the study was to explore which surgical site wound dressings healthcare professionals use when caring for a patient with a surgical wound, defined as any wound healing by primary intension. Our survey was designed to gain an insight into the frequency of postsurgical dressing changes and dressing type chosen.

METHODS

A semi-structured questionnaire was distributed via the Tissue Viability Facebook page via a Survey Monkey link. There was no inclusion/exclusion criteria, the survey was posted on the closed Facebook site only open to UK tissue viability nurses. All responses were anonymous, with consent being implied through survey completion. Institutional ethical approval was submitted and successfully received from the University of Huddersfield School of Human and Health Sciences Research Ethics and Integrity Committee (Ref: SREIC/2021/095). All data were stored on an encrypted University of Huddersfield server. Data were analysed by a biomedical statistician.

Table 1. Summary of respondent characteristics	
Variable	**Frequency (valid %)**
Main place of work (n=98)	
Acute	37 (37.8%)
Community	35 (35.7%)
Nursing/care home	4 (4.1%)
Primary care (GP surgery etc)	16 (16.3%)
Others	6 (6.1%)
Current pay grade/band (n=98)	
4	4 (4.1%)
5	22 (22.4%)
6	30 (30.6%)
7	26 (26.5%)
8a	9 (9.2%)
8b	4 (4.1%)
Other	3 (3.1%)
Average number of postoperative surgical wounds treated per month (n=98)	
Do not treat post-operative surgical wounds	17 (17.3%)
1–10	51 (52.0%)
11–20	15 (15.3%)
21–30	5 (5.1%)
31–40	1 (1.0%)
41–50	2 (2.0%)
Over 50	7 (7.1%)

Statistical methods

The sample was summarised descriptively, with responses relating to participant demographics and use of wound dressings tabulated. Key variables were also cross-tabulated to investigate possible associations between variables.

Health economics analysis

An economic analysis was conducted to estimate average weekly costs associated with changing and applying dressings, including both staff and equipment costs. Estimates of weekly staff time spent in changing and applying dressings were derived from estimates of the mean number of dressing changes per patient made by a nurse of a particular grade over a typical week; calculated from reported survey data; and assuming a time of 30 minutes to apply a dressing. Hourly staffing costs were estimated from these times using intermediate step points from nurses' annual pay scales assuming a 37-hour week (NHS Employers, 2021).

Equipment costs were estimated from average cost estimates of all reported specific dressing types (excluding disposable negative pressure dressings), applying costs to the reported distribution of use of each dressing type by a nurse of a particular band. Staff and equipment costs were summed to yield total estimated weekly costings associated with applying and changing dressings by nurses of specified bands.

RESULTS

Responses were obtained from 98 respondents whos characteristics are summarised in *Table 1*.

Most of the participants main place of work was in the acute or community settings, working at Bands 4, 5 or 6 (*Table 1*). Around half the respondents reported treating between 1 and 10 postoperative surgical wounds per month, with approximately 30% of respondents treating over 10 per month, 17% did not treat postoperative surgical wounds (*Table 1*).

Respondents reported using a wide variety of dressing types with non-adherent dressings the most common type (22%), followed by foam dressings (19%), dressings with active antimicrobial agents such as silver and iodine (14%) and silicone dressings (13%; *Table 2*).

Table 2. Summary of dressing use

Variable	Frequency (valid %)
Type of dressing most frequently used (n=98)	
Non-adherent	22 (22.4%)
Dressings with active antimicrobial (silver, iodine etc.)	14 (14.3%)
Dressings with non-active antimicrobial (Sorbact, Leukomed etc.)	8 (8.2%)
*CMC	2 (2.0%)
Hydrocolloid	4 (4.1%)
Silicone	13 (13.3%)
Foam	19 (19.4%)
Disposal Negative Pressure e.g. †PICO, §SNAP	5 (5.1%)
Other	11 (11.2%)
Main influence on choice of dressing (n=97)	
Following local guidance and formulary	65 (67%)
Advised to use by surgeon	5 (5.2%)
Advised to use by TVN	8 (5.4%)
Personal preference	12 (12.4%)
Only dressing available	7 (7.2%)
Frequency of dressing change (assuming no signs of infection) (n=98)	
Once a day	2 (2.0%)
Three times a week	5 (5.1%)
Twice a week	36 (36.7%)
Once a week	33 (33.7%)
For the medical round	1 (1.0%)
When the closure method is due for removal (e.g. suture removal)	7 (7.1%)
Other	14 (14.3%)
Choice of dressing changed by infection (n=98)	
Yes	94 (95.9%)
No	4 (4.1%)
Wound dressing used in cases of infection (n=93)	
Antimicrobial	46 (49.5%)
Dressings with active antimicrobial, e.g. silver, iodine, etc.	26 (28.0%)
Dressings with non-active antimicrobial, e.g. Sorbact, Leukomed, etc.	4 (4.3%)
Antimicrobial/Foam/Silicone	4 (4.3%)
Non-adherent dressings	3 (3.2%)
Foam	2 (2.2%)
Disposal Negative Pressure, e.g. †PICO, §SNAP	1 (1.1%)
Dressing with active/non-active anti-microbial	6 (6.5%)
Depends on the wound type	

CMC = Carboxymethyl cellulose, †PICO, §SNAP (Disposable Negative Pressure devices), TVN = Tissue Viability Nurse

The main reason for selecting the dressing of choice was influenced mainly by the local guidance and formulary (67%) followed by personal preference (12%); advice from a TVN (8%); the only dressing available (7%) or advice by the surgeon (5%; *Table 2*).

Of the respondents 37% reported changing wound dressings once or twice a week when there were no signs of infection; with smaller numbers changing dressings at lower or higher frequencies (*Table 2*). Almost all respondents would consider changing the type of dressing they used if they noticed that a wound was infected.

Economic evaluation: staff costs

The relationship between frequency of dressing change and current pay grade/band was investigated. Non-specific time periods ('For

Table 3. Main place of work by current pay band								
Frequency of dressing change	**Current pay grade/band**							
	4	**5**	**6**	**7**	**8a**	**8b**	**Other**	**Total**
Once a day	0	2	0	0	0	0	0	**2**
Three times a week	1	2	2	0	0	0	0	**5**
Twice a week	1	4	16	9	1	2	3	**36**
Once a week	2	7	8	10	5	1	0	**33**
Other	0	7	4	7	3	1	0	**22**
Total	**4**	**22**	**30**	**26**	**9**	**4**	**3**	**98**

medical round'; 'When due for removal' and 'Other') were merged into a single category. Data is tabulated in *Table 3*. Nurses on lower band/grades appear more likely to change dressings more frequently than those on higher grades.

This data was used to estimate the mean number of dressing changes per patient made by a nurse of a particular band over a typical week, and correspondingly the expected weekly time spent in changing and applying dressings by nurses on each band, assuming an average time of 30 minutes to apply a dressing. Due to low frequencies of respondents at Bands 4, 5, 8a and 8b, the expected frequency of dressing changes conducted by nurses in Bands 4 and 5 was estimated from data pooled over these bands; and similarly, the expected frequency of dressing changes conducted by nurses in Bands 8a and 8b was estimated from data pooled over these bands. Expected weekly staffing costs associated with dressing changes, are summarised in *Table 4*.

Table 4. Expected weekly staffing costs associated with dressing changes

Band	Expected dressing changes per week	Estimated time spent in dressing	Associated staff costs	Expected weekly staffing costs associated with dressing change
4	2.21*	66.3 minutes	£12.93	£14.29
5	2.21*	66.3 minutes	£14.43	£15.94
6	1.77	53.1 minutes	£17.76	£15.72
7	1.47	44.1 minutes	£21.89	£16.09
8a	1.33†	40.0 minutes	£26.08	£17.39
8b	1.33†	40.0 minutes	£30.83	£20.55

**Combined estimate from reported data from Band 4 and Band 5 nurses; †Combined estimate from reported data from Band 8a and Band 8b nurses*

Table 5. Equipment and total expected weekly costs associated with dressing changes

Band	Dressing costs per dressing change*	Expected weekly equipment costs associated with dressing change	Total expected weekly costs associated with dressing change**
4	£2.31†	£5.11	£19.40
5	£2.31†	£5.11	£21.05
6	£1.75	£3.10	£18.82
7	£2.23	£3.28	£19.37
8a	£1.78§	£2.37	£19.76
8b	£1.78§	£2.37	£22.92

*1*Calculated from the distribution of dressing types reported by nurses in that band; †Combined estimate from reported data from Band 4 and Band 5 nurses; §Combined estimate from reported data from Band 8a and Band 8b nurses; **Staffing costs plus equipment costs*

Economic evaluation: dressing costs

The average costs of all reported dressing types (excluding disposable negative pressure dressings which are not included in the calculation) are as follows:

- Non-adherent: £0.22
- Active antimicrobial dressing: £4.41
- Non-active AMD: £2.77
- Carboxymethyl cellulose: £5.94
- Hydrocolloid: £2.15
- Silicone: £1.78
- Foam: £1.90

The average cost of a typical dressing change by a nurse of a given band, calculated by applying the estimated frequency of use of each dressing type by a nurse of a particular band, is summarised in *Table 5*.

Hence there is little variation in the expected weekly costs associated with dressing change across bands, with lower staffing costs associated with nurses on lower bands partially offset by the generally higher frequencies of dressing changes conducted by these nurses. Staffing costs comprised the larger component of total costs for nurses of all bands.

DISCUSSION

In seeking to understand the potential barriers and opportunities available in routine surgical care for the wider introduction and use of wound imaging, this online survey has provided key factors relevant to the implementation of technology in wound care.

It is now recognised that technology development and uptake in the NHS is dependent not only on the potential to reveal pathology not observable by existing assessment practices, typically 'by eye'; but also on its adoption within the healthcare service. In the case of medical imaging of surgical (and chronic) wounds, the site must be exposed and visible to the detector. However, in contemporary wound care, dressings obscure the wound from view until they are removed. For wound imaging to evolve, it is necessary to understand how any potential benefit of imaging within the patient care pathway could be achieved, whether a route offering new methods of wound assessment is feasible in routine care, and if there is evidence of cost-benefit.

These data reveal that the largest type of dressing products currently in use were non-adherent, with dressing changes taking place approximately twice per week; more frequently if wounds were assessed/diagnosed as infected. This interval of dressing change holds some promise for wound imaging to be 'woven' into routine care protocols. However, frequent removal and reapplication of dressings and the potential for delaying wound healing has been discussed in the context of undisturbed wound healing (Rippon et al, 2012). Furthermore, Rippon et al (2015) argue that through mechanical disturbance to the healing process, temperature loss at the wound site (affecting the cellular healing process) and potential increase in the ingress of harmful bacteria to the wound site is influenced by the dressing properties; not all having the same properties to maintain 'wear time'. Thus, while dressings may remain *in situ*, they may not continue to provide the essential characteristics existing at the outset. If loss of dressing efficacy is apparent, dressings are likely to be changed outside of any local dressing change protocol.

In this study, most dressings were changed, on average, twice per week and typically according to local guidance for practice. Furthermore, Blackburn et al, (2018) exploring staff reasoning for changing of wound dressings, identified that the primary reasons for dressing change was wound inspection followed, as we have observed, by adherence to local protocol as well as the practicalities of community nurse visits. For example, if nurses visited on a Monday and Thursday, these days would be the times for wounds to be inspected and redressed. Thus, while local protocols serve as a guide to dressing type and dressing change practices, nurses recognise the importance of wound assessment. There is scope within current routine care to allow for regular dressing changes specifically (Blackburn et al, 2018), because wound assessment is judged to be a top priority and a factor in decisions concerning the need for a dressing change.

Balancing the cost of dressings and the frequency of changing them allows for an economic evaluation: a key component in the introduction and potential success of introducing any new healthcare technology to the market and subsequently adoption by the NHS. Excluding costs for NPWT, list prices for PICO dressings range from £127.06 to £145.68 (including VAT). In this study, unit costs of all dressing types used were below £6.00. By far the most common were non-adherent dressings, which are associated with minimal costs. Removal of all dressing types reported incur very little cost and with changes of dressings taking place most typically twice each week, such commonly used protocols and practices allow for regular wound imaging; such that early identification of SSI using imaging technologies could ensure early intervention in the prevention of wound infection.

The use of fluorescence-based clinical tools has been well established (Raizman, 2019; Serena et al, 2019) to provide real-time information on the bioburden, however it should be noted that the survey did not request information regarding fluorescence-based clinical tools. Some authors (Childs et al, 2016; 2019; Siah et al, 2019) have identified a potential role of non-invasive infrared thermography to stratify risk of later SSI, based upon the temperature distribution across wound site and adjacent skin territories. Furthermore, new approaches to wound assessment for complications of incisional fluid collections using smartphone-based ultrasound systems have been developed (Barrett et al, 2016). With over half of patients with fluid collections going on to develop SSI, surgical wound assessment by sonography (SWATS) has potential for early prognosis of SSI and with only one participant excluded from the study due to the presence of bandages, such studies support the case for wound imaging assessment, despite the use of dressings in routine care.

With nurses recognising the primary importance of wound assessment, the balance between dressing application, dressing change and wound imaging technologies has a potential place in modern wound care. The ability to be able to detect early signs of SSI in an objective way is paramount in achieving timely interventions that can reduce hospital inpatient stays, community visits, antimicrobial usage, patient morbidity and healthcare costs related to wound infection.

By undertaking this study in a cohort of practising nurses regularly treating surgical wounds, the results hold promise for the future and wider implementation of imaging technologies in wound care. Whether incorporated into the routine wound management protocols, or as a justifiable adjunct to wound inspection, dressing change is inevitable if the priority is to assess the wound for signs of infection but without unnecessary disturbance of healing. Of importance here is the apparent low use of expensive NPWT: a finding counter to expectation. It is not yet clear why the frequency of NPWT was just 5% approximately, but possibilities include high cost, lack of clear evidence of SSI reduction (Whibey et al, 2018; Webster et al, 2019) and concerns about increased incidence of skin blistering (Gillespie et al, 2021).

Limitations

However, some limitations should be borne in mind: the greater number of bands 5, 6 and 7 limits the precision of estimates that may be obtained from these sub-groups. Staffing time is based on a fixed estimate of 30 minutes per dressing. It is recognised that there are other costs associated with staffing, besides salary; these are not accounted for in the current analysis.

It would be expected that there would be some variation in actual time spent in in applying and changing a dressing. Staff at different bands may be assigned to the treatment of wounds that may vary considerably in size, severity and anatomical location, with a corresponding expected variation in time required to apply and change a dressing. In addition, the costs associated with each dressing type will vary. Here the values used represent mid-points of an estimated range of costs in each case. Furthermore, although band mid-points have been used in calculating staffing costs, the exact staffing cost is not known, as nurses' salary varies within bands, depending on the duration of tenure at a particular band.

CONCLUSIONS

The largest type of dressing products currently in use were non-adherent. Dressing changes took place approximately twice per week: more frequently if wounds were assessed/diagnosed as infected. The majority of wound assessment and dressing changes were undertaken by band 5, 6 or 7 nurses. Confidence in wound assessment is key to ensure appropriate wound dressings are chosen and dressings changed in a timely manner based on wound bed assessment. There is a potential role for non-invasive infra-red thermography to stratify risk of later SSI based upon the temperature distribution across wound site and adjacent skin territories. Early and objective interventions for early wound infection can reduce hospital in patient stay, reduce community visits, reduce antimicrobial usage, reduce patient morbidity and reduce healthcare costs related to wound infection. WUK

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