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Glove and instrument changing to prevent bacterial contamination in infected wound debridement and closure procedures: A prospective observational study

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Abstract

Many surgeons use a single table of instruments for both excisional debridement and coverage/closure of infected wounds. This study investigates the effectiveness of a two-table set-up of sterile instruments, in addition to glove exchange, to reduce instrument cross-contamination during these procedures. This is a prospective, single-site, institutional review board-approved observational study of surgical debridements of infected wounds over a 17-month period. Two separate sterile surgical tables were used for each case: Table A for initial wound debridement (debridement set-up) and Table B for wound coverage/closure (clean set-up). Swabs of each table and its respective instruments were taken after debridement but prior to coverage/closure. The primary outcome of interest was bacterial growth at 48 hours. There were 72 surgical cases included in this study. Culture results of Table A demonstrated bacterial growth in 23 of 72 (32%) cases at 48 hours compared with 5of 72 (7%) from Table B ($P = .001$). These data suggest that there is significant bacterial contamination of surgical instruments used for debridement of infected wounds. Use of a two-table set-up reduced instrument cross-contamination by 78%, suggesting avoidable re-contamination of the wound.

KEYWORDS

debridement, equipment contamination, surgical instrument, surgical gloves, surgical site infection

1 | INTRODUCTION

Excisional (surgical) debridement is one of the most effective treatments for chronic wounds with frequent biofilm-related conditions, physically removing biofilm from the wound area.[1] In addition to decreasing the bacterial load, debridement removes unhealthy tissue and debris, which may act as a nidus for bacteria and promote chronic inflammation.[2] During excisional debridement, a chronic wound is transformed into an acute wound so that the process of normal wound healing can restart.[3]

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Even with surgical debridement, however, failure to adequately clear infection in chronic wounds remains a possibility. Re-infection of the wound can lead to drastic consequences, such as limb amputation, which have serious implications on patient quality of life and mortality.[4,5] A study by Tan et al reported a deep infection recurrence rate greater than 50% in diabetic foot ulcers following surgical debridement, leading to above-knee amputations in 8.7% of patients.[6] Infection recurrence following surgical debridement is not limited to chronic wounds. In the orthopaedic literature, irrigation and debridement of periprosthetic knee infections has been associated with a recurrence rate of 18%.[7] Similarly, a study by Bryan et al found a surgical debridement failure rate of 17% in patients with infection following hip arthroplasty, leading to hardware removal in 10% of patients.[8] The existing literature suggests that surgical debridement may not completely eradicate infection, which can have devastating sequelae. It is therefore of critical importance to minimise patient and environmental risk factors that may predispose a patient to re-infection during or after surgical debridement.

This study was prompted by the concern that contamination of surgical instruments by necrotic and infected tissues during excisional debridement may contribute to re-infection of the clean wound bed following debridement. The aforementioned studies all conducted surgical debridements using a single-instrument-table set-up. The authors of this study have previously advocated for the use of two separate sets of instruments to prevent possible cross-contamination, thereby lowering the risk of subsequent re-infection.[3] This study investigates the efficacy of glove changing and use of separate instrument trays for debridement and wound closure in reducing instrument cross-contamination during excisional debridement and closure of infected wounds.

Key Messages

- surgical debridement of infected wounds is an inherently non-sterile process, and contaminated surgical instruments and gloves may act as vehicles for bacterial contamination of a clean wound bed during wound closure following excisional debridement
- the aim of this study was to investigate the efficacy of glove changing and use of separate instrument trays for debridement and wound closure in reducing instrument cross-contamination during excisional debridement and closure of infected wounds
- the results of our study demonstrate that instruments used during debridement were significantly more likely to be contaminated compared with instruments kept separate for wound closure and that a two-table set-up reduced instrument cross-contamination by 78%.

2 | MATERIALS AND METHODS

We assess cross-contamination between dirty instruments from the debridement set-up, which are used for the initial removal of infectious tissue, and clean instruments from the clean set-up, which are used for wound coverage or closure, and hypothesise that a two-table set-up and glove exchange decrease bacterial cross-contamination between the two sets of surgical instruments.

2.1 | Study design

This is a prospective, single-site, institutional review board-approved observational study conducted at a single institution over a period of 17 months. We routinely use two instrument tables for surgical debridement of infected wounds; thus, this study did not implement a protocol change that would have been outside of our institution's regular practice. This study was therefore considered observational in nature. Screening was performed to identify patients receiving an initial surgical debridement for a clinically infected wound. No patient information was collected for the purpose of this study.

2.2 | Surgical protocol

All excisional debridements were performed in a standard operating room (OR). Each OR was stocked with two separate sterile surgical tables: Table A was used for initial wound debridement ('debridement set-up') and Table B for wound coverage/closure ('clean set-up') (Figure 1). Table A and Table B contained identical surgical instruments opened at the start of the procedure. Table A was stationed 1 ft from the surgical sterile field drapes and was used for the initial excisional debridement of the infected wound. Table B was stationed a minimum of 3 ft from the surgical field during the initial excisional debridement. During irrigation, Table A was moved at least 3 ft from the operative field and use of these instruments was discontinued for the remainder of the surgery. Following irrigation, re-draping of the operative field, replacement of suction and cautery, and

re-gloving of all scrubbed personnel, Table B was restationed 1 ft from the surgical field. Table B instruments were used for the remainder of the procedure, which typically involved haemostasis and coverage/closure.

All patients presented with infected wounds based on clinical judgement in conjunction with laboratory markers of infection (ie, leukocyte count, wound cultures, systemic signs, etc.). Surgical debridement of the infected wound was performed in the OR according to the standard of care. This procedure uses various standard surgical instruments including but not limited to scissors, scalpel, curette, and rongeurs. Wounds were irrigated with 3 L of normal saline immediately following debridement. Re-draping of the patient, re-gloving of all scrubbed persons, and exchange of instrument tables were conducted following irrigation.

After changing gloves, swab cultures were taken from the instrument tray and the instruments (needle driver, scalpel blade, curette, pick-ups) on Table A followed by swab cultures of the instrument tray and instruments on Table B with a separate culture probe. Swabbing of the instruments involved sweeping across all the surgical instruments listed above in a single swipe and a single swipe across the instrument tray using the same probe. Cultures were placed in an isolation bag and transported for processing. Aerobic and anaerobic cultures were performed for each swab.

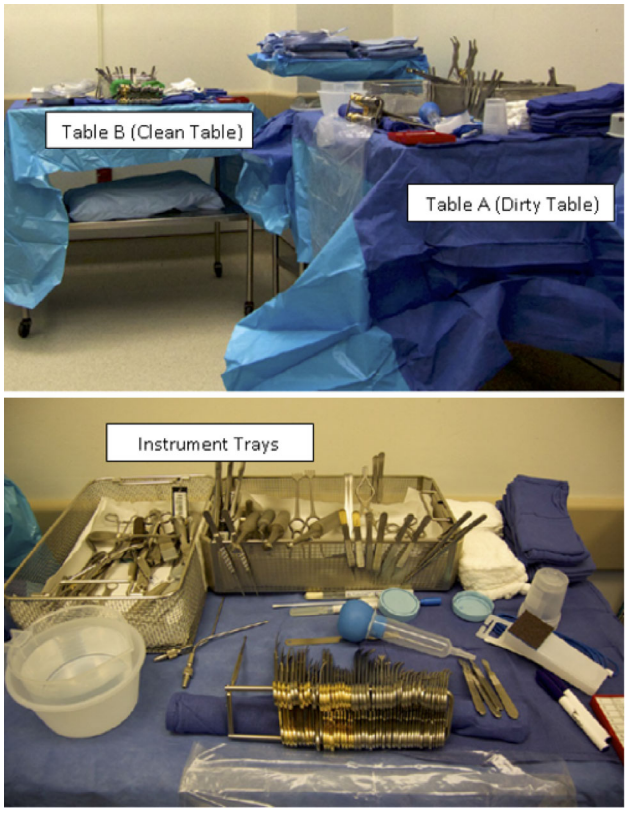

FIGURE 1 Two-table set-up. The two tables are imaged in the top panel showing two complete sterile field set-ups and instruments. The bottom panel shows the instruments laid out on each table

2.3 | Data and statistical analysis

Bacterial cultures were assessed in a binary fashion ('growth' or 'no growth') 48 hours after collection. The primary outcome of this study was results of bacterial cultures at 48 hours after collection. Bacterial loads were not quantified nor were species identified. The McNemar statistical test was used to compare the frequency of bacterial growth from specimens obtained from Table A vs Table B for each case. Statistical significance was defined as $P < .05$.

3 | RESULTS

A total of 144 swab samples were collected from 72 surgical cases. Table 1 summarises the results of these cultures. Culture results of Table A demonstrated bacterial growth in 23 of 72 (32%) cases at 48 hours contrasted with 5 of 72 (7%) from Table B ($P < .0001$). All five swabs from Table B with growth at 48 hours corresponded to positive cultures in Table A during the same surgical case. Of the 23 cases from Table A with positive swabs at 48 hours, the majority (78%) did not have corresponding positive swabs from Table B.

In instances where Table A was contaminated, using the two-table set-up reduced the risk of Table B being contaminated to 22%, representing a 78% absolute risk reduction, assuming a 100% cross-contamination rate.

TABLE 1 Swab culture results from surgical instruments and instrument tray

	Table A (dirty) N = 72	Table B (clean) N = 72	*P*-value
Growth at 48 hours	23 (32%)	5 (7%)	**<.0001**
No growth at 48 hours	49 (68%)	67 (93%)	

Note: Frequency of bacterial growth was compared using the McNemar statistical test.

4 | DISCUSSION

Many surgeons use a single table of instruments for both excisional debridement and coverage/closure. We explored the value of using a clean, second table following debridement and washout, in addition to glove exchange. Notably, Table B in our study represented a separation of time and space from potential contamination that may have occurred with Table A during debridement.

This study found a contamination rate of 32% of instruments from Table A used for initial debridement, significantly higher than the 7% of instruments from Table B found to be contaminated. Thus, in cases where instruments on Table A were found to be contaminated, using a two-table set-up reduced the risk of cross-contamination of Table B instruments by 78%. Table B cultures did not exhibit bacterial contamination in 93% of the studied cases. Furthermore, there were not any positive Table B cultures without corresponding positive Table A cultures. These findings suggest that aerosolisation does not significantly contribute to bacterial contamination of instruments in the clean set-up.

Many surgeons have investigated the pervasiveness of bacteria within the OR even in instances of strict adherence to sterile technique. Boekel et al demonstrated that microparticles from contaminated fields can travel up to 22.7 cm onto a sterile field.[9] In a study of 50 head and neck cancer resections, Mazurek et al showed that 81% of surgical fields/drapes were contaminated with bacteria within 2 hours of surgery start time.[10] The authors also reported three surgical site infections, two of which had positive swabs during the surgery.[10] These studies suggest that despite sterile technique in 'clean' fields, significant contamination may occur if a contamination source exists nearby. A case series in 2012 from the United Kingdom's National Health Service identified contaminated surgical instruments as the cause of infection in 20 'clean' surgeries, highlighting the infectious risk of contaminated surgical instruments.[11]

The concept of a two-table set-up has long been used in oncologic surgery in order to avoid seeding of cancerous cells. Upon completion of surgical tumour resection, gowns, gloves, surgical drapes, and instruments are routinely changed prior to closure of the surgical defect to limit exposure to exfoliated tumour cells. Studies have supported the existence of exfoliated cancer cells on surgical instruments; however, no consensus on the management of gloves and instruments for oncologic surgeries has been established.[12,13] Yu et al. examined the exfoliation of gastric carcinoma during gastrectomy for non-metastatic gastric carcinoma. Surgical instruments, sponges, surgeon's gloves, scrub nurse's gloves, and stapler devices were collected in five separate containers. Despite 6-cm margins from the tumour, appropriate operative technique, and absence of carcinomatosis or extension through serosa, exfoliated tumour cells were still found on all sample groups. Gloves worn by the scrub nurse and gauze used during the surgery were the most likely to be contaminated by exfoliated gastric carcinoma cells. Interestingly, even the surgical staplers that were fired at least 6 cm away from the tumour were found to be positive up to 3.3% of the time.[14] This highlights the ability of exfoliated cells to move from one location to another within a controlled, sterile field.

Evidence regarding the ability of cancer cells on instruments or gloves to actually cause tumour seeding or recurrence is limited.[15] In a recent survey of 351 surgeons, 52% reported changing gloves and 40% reported changing instruments specifically to reduce the risk of tumour seeding. Of respondents, however, 94% stated they would be willing to change their behaviours if presented with evidence of potential benefits.[15] Based on this study, changing gloves and instruments to prevent tumour seeding is not uniformly practised and concrete evidence exploring its benefits is warranted.

Similarly, the evidentiary basis for glove and instrument changing to prevent spreading of infection to a presumed clean wound bed is lacking. Makki et al conducted a small study comparing two rounds of biopsy sampling from foot and ankle infections during surgical debridement. Fresh, sterile instruments were used at each site in the first round. One set of instruments was used for all sites in the second round. The rate of cross-contamination was significantly higher ($P = .002$) in the reused instrument group compared with the zero cross-contamination that occurred in the fresh instrument group.[16] Assuming similar principles of microscopic contamination, it can be inferred that the use of contaminated instruments in a clean, surgical wound bed increases the risk of bacterial inoculation. Although the bacterial load from cross-contamination was not quantified by Makki et al, the study suggests that the principles of cross-contamination from surgical instruments in musculoskeletal infections exists.[16]

Although infected wounds are not sterile, intraoperative contamination leading to further infection should not be accepted as an unavoidable complication. A meta-analysis of primary closure of contaminated abdominal wounds showed a 75% success rate of primary closure without surgical site infection.[17] Furthermore, purulent or feculent diverticulitis, which involves an unquestionably contaminated operative field, has been successfully treated in a single-stage procedure with primary closure, with recurrent intra-abdominal infection rates as low as 8%.[18] Our study indicates that when

operating in infected and contaminated fields, bacterial spread can be mitigated. We have demonstrated that use of a two-table set-up can reduce cross-contamination by as much as 78%.

Despite the effectiveness of this two-table method in reducing instrument cross-contamination, the method failed to completely eliminate instrument cross-contamination. Out of our 72 surgical cases, five demonstrated growth in Table B cultures. As these instruments were unused prior to swabbing, contamination may be attributed to aerosolisation of bacterial contaminants. Studies investigating bacterial aerosolisation in the OR have found that OR ventilation, patient warming blankets, and high-pressure hydroscalpels can lead to significant bacterial aerosolisation.[19-21] However, the tables in our study were placed at least 3 ft away from the operative field prior to use, which is much further than the 22.7-cm migration of bacteria discussed by Boekel et al, decreasing the likelihood of aerosol contamination.[9] In addition, there were no positive cultures from Table B without corresponding cultures from Table A. Further investigation is needed to determine possible alternative routes of instrument contamination.

We did not speciate or quantify the bacteria grown from our swabs, which precludes us from drawing conclusions regarding bacterial load or the reduction of inoculation into the clean wound bed. Our study is also limited by the lack of a control group in which only one instrument table was used. In addition, no patient or surgical site outcomes were followed up, thus limiting the long-term clinical implications that can be drawn from this study. Because of these limitations, we cannot comment on the implications of instrument contamination or the pathogenicity of the contaminating species on postoperative outcomes. Patient outcomes would add valuable insight into the clinical impact of surgical instrument cross-contamination. Additional studies are needed to assess whether a two-table set-up can improve clinical outcomes, such as wound-healing rates, re-infection, and subsequent amputation. The justification of increased cost and OR time with this intervention is also limited, apart from a 78% reduction in cross-bacterial contamination, because of lack of controls and patient-specific outcomes data. Finally, this study only captured patients with clinically infected wounds at their first debridement and did not include patients with merely colonised or sub-clinically contaminated wounds.

5 | CONCLUSION

Intraoperative protocols should aim to mitigate risks related to surgical site infection complications, such as dehiscence, necrotising fasciitis, and amputation. The findings of this study demonstrate that significant instrument contamination can occur during debridement of infected wounds. Although oncologic surgeries frequently use separate gloves, drapes, and instruments to reduce the exposure of the patient to cancerous cells, surgical debridement of infected wounds has not yet widely adopted this technique. We found that using a second sterile instrument table for instruments used after debridement only for coverage or closure can reduce contamination by up to 78%, justifying the increased costs and operative time required for the two-table set-up. To our knowledge, this is the first study examining the sterility of operative instruments during excisional debridement of clinically infected wounds. Future studies should assess the potential of a two-table set-up to reduce recurrent infection of chronic wounds, which may subsequently lead to a decrease in procedures, length of stay, antibiotic use, and overall cost of wound management.

CONFLICT OF INTEREST

There are no financial disclosures, commercial associations, or any other conditions posing conflict of interest to report for any of the above authors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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