Considerations for a Post-Surgical Wound Dressing Aligned with Anti-Microbial Stewardship Objectives: A Scoping Review

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ABSTRACT

Background: Most surgical wounds heal by primary intention or secondary intention. Surgical wounds can present specific and unique challenges including wound dehiscence and surgical site infection, either of which can increase risk of morbidity and mortality. The use of antimicrobials to treat infection in these wounds is prevalent, but there is now an imperative to align treatment to reduce antimicrobial resistance and align with antimicrobial stewardship.

Aim: To explore the published evidence identifying general considerations/criteria for a post-surgical wound dressings in terms of overcoming potential wound healing challenges (including infection) whilst also supporting Anti-Microbial Stewardship (AMS) objectives.

Methods: A scoping review examining evidence published from 1954 to 2021, conducted by two authors acting independently. Results were synthesised narratively and have been reported in line with PRISMA-ScR.

Results: A total of 819 articles were initially identified and were subsequently filtered to 178 articles for inclusion in the assessment. The search highlighted six key areas associated with post-surgical wound dressings: wound infection, wound healing, physical attributes related to comfort, conformability and flexibility, fluid management (e.g., blood and exudate), pain and skin damage.

Discussion: This scoping review has highlighted several unique challenges for post-surgical wound dressings and areas that require further investigation to enhance clinical outcomes. Of particular importance is the impact of SSIs remaining a significant burden and that some antimicrobial dressings reduce the risk of resistant microorganisms so as such can be successfully aligned with an AMS strategy.

Conclusion: There are several challenges that can be overcome when treating a post-surgical wound with a dressing, not least the prevention and treatment of SSIs. However, it is imperative that the use of anti-microbial dressings should be aligned with AMS programs and alternatives to active anti-microbials be investigated.

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Key words: Surgical wounds, Surgical Site Infection, criteria, post surgical, wound, dressing, antimicrobial stewardship

Reflective questions

- Define a surgical wound
- How are most surgical wounds closed?
- Identify two unique challenges for post-surgical wound dressings
- What can be used to prevent Surgical site infections?

INTRODUCTION

A surgical wound has been defined by the World Health Organisation as "a wound created when an incision is made with a scalpel or other sharp cutting device and then closed in the operating room by suture, staple, adhesive tape, or glue and resulting in close approximation to the skin edges" (p. 10, Health Organisation, Global guidelines for the prevention of surgical site infection[1]). Worldwide, an estimated 4511 operations per 100,000 population occur annually, equating to one surgical procedure each year for every twenty-two people.[2] Most surgical wounds are primarily closed using sutures, staples, or adhesive glues[3] and can, if required, be covered with simple wound dressings.[4] Surgical wounds may be allowed to heal by secondary intention. For example, Chetter et al[5] in a cohort study followed patients with a surgical wound (e.g., planned surgical procedures, surgically re-opened) at a variety of locations (e.g., abdomen, foot, leg, natal cleft) which were left to heal by secondary intention. Wounds such as these may require the use of more advanced dressings.

There are several complications associated with surgical wounds, including surgical site infection (SSI), wound dehiscence, hypergranulation, peri-wound maceration, poor or abnormal scarring, and medical adhesive-related skin injury.[6] The management of surgical wounds, and identification of criteria of an 'ideal' post-surgical wound dressing to prevent said complications have been the subject of debate for decades.[7-10] A myriad of wound dressings are available on the open market, and research continues into the optimal dressing to reduce SSI.[11,12] The prevention of SSI has been a particular focus, with researchers and international bodies alike developing advice and guidance to meet this challenge.[1,13]

SSI are the second most prevalent healthcare-acquired infection in Europe and the USA,[1] and can have significant consequences. At least 5% of patients undergoing a surgical procedure develop a surgical site infection.[13] The incidence of SSIs can vary across surgical procedures, specialties, and conditions, with a range of 0.1% to 50.4% being reported.[14] It is a burden for the patient, with an additional 11 days of hospitalization for each SSI.[15] The presence of biofilms has also been identified as an important factor in the development of SSIs,[16] and have been associated with delayed healing, prolonged hospital stays and unnecessary pain,[17] which impacts on the need for increased medical resources and associated increases in healthcare costs.[18-20] The additional cost associated with SSI was reported in a recent systematic review as being \$174-\$29,610 per patient for low- and middle-income countries (LMICs) and \$21-

$34,000 per patient for European countries.[21] These estimates were based upon additional healthcare costs. One study, that examined broader societal costs (e.g., cost of productivity loss, informal care as well as healthcare costs) estimated an additional total costing of $145,366 per patient, with healthcare costs contributing only 10.5% of these costs.[22]

In parallel with an increased number of surgical procedures worldwide, and a relatively static number of wound infections, antimicrobial resistance (AMR) has become a significant threat to global health. The World Health Organization proclaimed AMR as one of the top 10 global public health threats facing humanity[23] and in 2019 alone there were an estimated 4.95 million (95% uncertainty interval [UI] 3.62-6.57) deaths associated with bacterial AMR in 2019, and that 1.27 million (95% UI 0.911-1.71) deaths were directly attributable to bacterial AMR.[24] Within wound care, AMR has also been identified as a serious cause for concern.[25,26] Clearly there is a need for preventative strategies for SSI and other wound complications, but also for this to be aligned with the principles of antimicrobial stewardship (AMS), the set of actions which underpin and promote the sensible and responsible use of antimicrobials.[27]

The aim of this study was to examine, and summarise the current published evidence discussing general considerations/criteria for a post-surgical wound dressing used in wounds healing by primary intention in terms of overcoming challenges (including infection) these wounds present.

METHOD

A scoping review[28,29] was conducted to map the research to date on post-surgical wound dressings, the alignment of a post-surgical wound dressing with antimicrobial stewardship objectives, and to identify any existing gaps in knowledge. Our process broadly followed the process as set out by Arksey and O'Malley,[30] as well as following the PRISMA Extension for Scoping Reviews (PRISMA-ScR) checklist.[31]

Table 1 summarises the search strategy. A comprehensive literature search using PubMed/MEDLINE was performed in January 2021 using the following search strategy (Search 1, Table 2). This search strategy identified a variety of post-surgical wounds including split thickness donor sites and laser resurfacing studies which were included in the assessment. Articles published between January 1954 and December 2020 (inclusive) were searched. In addition to the database search, relevant articles previously known by the authors, but which are not indexed in PubMed were added as "ad hoc" articles. The review was limited to studies within the Oxford Centre of Evidence-based Medicine guidelines' Level of Evidence I-IV.[32] Articles were identified for potential inclusion by title, abstract and full text (where available).

A supplementary search strategy (Search 2, Table 2) was then carried out on the identified articles in order to remove articles related to negative pressure wound therapy (NPWT) (these wounds require dressings with specialised capabilities) and articles that were determined as being specifically unrelated (to this review) to surgical wounds (e.g., chronic wounds, periodontal wounds, burns or bone-related wounds) or require specialised dressings. Figure 1 shows a summary flow diagram of the literature search.

All titles and abstracts were screened for relevance against the research questions by the first and second author. For the first level of screening, two investigators independently screened the title and abstract of all retrieved articles for inclusion. Articles that were considered relevant by either or both reviewers were included in the subsequent review. Articles were included if: (i) they reported information on post-surgical wounds, (ii) the use of wound dressings used as part of the treatment, and (iii) data was available from clinical studies. Papers were excluded if: (i) they only reported information on non-clinical situations, or (ii) they were reviews, meta-analyses, or not written in English (Table 1). In the second step, two investigators then each independently assessed the abstracts and, where available, the full text of articles. Study characteristics were extracted (including – but not limited to – patient population healing response, dressing fluid handling and patient comfort characteristics, pain experienced, skin damage, and a description of infection status). Data extraction was conducted in duplicate with two reviewers independently extracting data from all included studies. When disagreement occurred with respect to inclusion or exclusion, discrepancies were discussed and a consensus was reached. The data was compiled in a single literature review EndNote database, and then downloaded into a single bespoke Excel spreadsheet in Microsoft Excel software. Eligible studies were studies identified in the PubMed/MEDLINE search using the designed search strategy describing the scientific and clinical evidence related to challenges in the use of post-surgical wound dressings for wounds healing by primary intention. The outcomes of interest were infection, wound healing, comfort, flexibility and conformability (comfort), fluid handling, pain, and skin damage (e.g., skin blistering and dermatitis).

RESULTS

The search identified 816 articles and three additional articles identified during the “ad hoc” search of journals not indexed in electronic literature databases (a total of 819): 322 remained after these 819 articles were subsequently searched and articles related to NPWT were removed. A further 144 articles did not meet the inclusion criteria leaving 178 for final inclusion (Figure 1).

Two-hundred and sixty-three outcomes of interest (e.g., study parameters including healing, physical attributes, infection, etc (Figure 1)) were identified in the 178 articles included of which 82 featured infection as a major aspect of the study objectives (Figure 1).

DISCUSSION

Our scoping review identified several themes identifying challenges associated with using post-surgical wound dressings for the prevention and management of SSIs.

CHALLENGES FOR POST-SURGICAL WOUND DRESSINGS

Surgical site infection

The role of a post-operative wound dressing in preventing SSI might be deemed to be inconsequential with the use of antimicrobials such as antibiotics and antiseptics,[13,33-36] being regarded as first line management. However, themes emerged from this scoping review suggesting that wound dressings may have attributes that can inhibit the ingress of organisms into wounds, such as enabling or quickening healing,[37,38] effective fluid management properties,[39,40] beneficial physical attributes (such as conformability, flexibility aiding patient comfort),[41,42] non-traumatic adhesion,[39,43] as well as containing antimicrobials that can help prevent or treat infections.[44,45]

The role of wound dressings in preventing SSI is still under investigation. A Cochrane Review concluded it was uncertain whether covering surgical wounds healing by primary intention with wound dressings reduces the risk of SSI, or whether any wound dressing was more effective than others in reducing the risk of SSI.[46] Additional studies not included in that review have also shown equipoise between covered or exposed surgical wounds, for example in patients that have undergone caesarean section.[47] However, other evidence has identified that post-surgical wound dressings can be effective in preventing infection wounds that are healing by primary intention.[46,48] Wound dressings with an antimicrobial action alter the wound bed bioburden. Predominantly delivering a sustained release of antimicrobial agents, these dressings provide antimicrobial action from silver, iodine or polyhexamethylene biguanide (PHMB), and come in a variety of delivery systems, shapes and sized.[49] In addition, newer dressings are available with antimicrobial action that do not rely on antimicrobial agents but, rather, use innovative materials to provide the antimicrobial action (e.g., DACC).[50] The use of post-surgical dressings with an antimicrobial action have been highlighted as being effective in preventing SSI following specific surgical procedures; caesarean section,[44] renal transplant,[51] sternotomy,[52] a variety of post-operative surgical wounds,[53] vascular surgery,[45,54] gynaecological surgery,[55] and colorectal surgery.[56] A study of 200 patients undergoing nonimplant vascular surgery were treated with either conventional dressings (n=100) or DACC-coated dressings (n=100) found that the use of DACC-coated dressings were associated with a significant reduction in SSI rates in the early postoperative period.[54] A pilot feasibility randomised controlled trial (RCT) in patients undergoing clean or clean-contaminated vascular surgery also showed a relative risk reduction for SSI at 30 days[45] and a large-scale RCT is underway to build on these early results.[57]

Some evidence does suggest that simple dressings are associated with reduced incidence of SSI by preventing post-operative complications (e.g., blisters in hip or knee arthroplasty[41]) and through superior fluid handling capacity (e.g., the use of hydrocolloid dressings after total joint arthroplasty surgical procedures[58]). Dressings with antimicrobial action that do not contain an “active” component, but which use “physical” methods of reducing bacterial load in the wound have been described (e.g., DACC-coated dressings).[25] However, it is important to note that there is very little information published on the use of these antimicrobial use in wound care (in general or in the treatment of surgical wounds) and how this aligns with AMS.

Healing in post-surgical wounds

Antimicrobial wound dressings, in particular those that do not contain an active component but instead have a physical mode of action to reduce bacterial load, help to promote AMS practices.[59] In surgical wounds healing by secondary intention a range of authors have highlighted the importance of optimisation of moisture within the wound environment using different dressing options: from simple dressings such as non-adherent dressings to more modern options such as foam, hydrocolloid or alginate dressings.[60,61] As such, there is a considerable amount of evidence that supports the use of a variety of different types of dressings for treating post-surgical wounds healing by secondary intention.[62-65]

Table 3 highlights properties of novel dressings aimed at enabling healing progression in post-surgical wounds.

Of the 178 articles included 83 discussed wound healing, although relatively few (n=2) measured wound healing as a specific study endpoint. Murthy et al[66] document positive outcomes for a group of post-caesarean section patients with wound gape treated with a papaya dressing. Time to induce healthy granulation tissue and total duration of hospitalisation were reduced compared with the control group. A small study assessing effective management of post-operative wounds that had dehisced treated with micro-grafts in combination with collagen sponge to form a “bio-complex dressing” promoted wound reepithelialisation and complete remission of dehisced wounds.[67]

Physical parameters (e.g., conformability, flexibility) of the post-surgical wound dressing

Comfort, conformability, and flexibility of dressings are important parameters for patient well-being and providing dressings that meet these criteria will result in better patient quality of life, healing outcomes and have an influence on wound infection.[68] Dressing flexibility was regarded as important post operatively in orthopaedic surgery to allow joint movement and promote early mobilisation,[69-72] allowing for the best outcomes in terms of joint range of motion, healing, patient well-being and prevention of deep venous thrombosis (DVT). Post-surgical dressings should not impede movement in such a way that makes physiotherapy and rehabilitation difficult.[73] Flexibility and conformability can prevent shearing, blistering and skin tears that may preclude development of infection,[74,75] although it has been identified that some post-surgical dressings are better than others at blister prevention (e.g., alginate and hydrofibre with hydrocolloid were ranked as the optimal dressings[76]). During this review, these factors were identified as being important characteristics of a post-surgical wound dressing, and 29 articles were identified that were specifically related to patient comfort. Dickinson Jennings et al[52] identified that measurement of comfort (of the post-surgical wound dressing) was either a primary or secondary outcome in clinical trials related to different surgical procedures (e.g., sternotomy), gynaecological surgery,[55] hip and knee replacement,[41] and knee arthroplasty.[40] Wearing comfort is a secondary outcome measure for 29 studies. For example, in a study of orthopaedic patients who had undergone surgery, treatment with an absorbent wound dressing was compared with treatment with a standard dressing (a non-woven self-adhesive fabric dressing).[39] Wearing comfort was an issue for a significant number of patients treated with the standard dressing: only 3.8% rated the standard dressing as “excellent” or “very good” for comfort, whereas 80.6% patients rated the absorbent dressing as “excellent” or “very good” for comfort ($p<0.001$). Treatment of post-surgical wounds with modern dressings – dressings that promote the establishment of a moist environment and enhanced functionality (e.g., enhanced exudate management)[77] – rather than conventional dressings improves the comfort of patients post-surgery.[55,78,79] A prospective clinical study evaluating the performance of a modern post-operative wound dressing (bordered foam dressing) versus a conventional dressing (gauze-based dressing) found that patient comfort and overall satisfaction was rated >95% for the modern dressing in both knee and hip arthroplasty patients.[78]

A wide range of wound dressings claim to have this “comfort factor” — most notable are those that have greater conformability and flexibility allowing application around awkward contours or bony prominences such as film dressings.[9]

Fluid management

One of the key requirements of a post-surgical wound dressing is effective fluid management in terms of limiting leakage of blood[80] or haemoserous exudate.[81] As a theme, effective fluid management and management of bleeding was discussed in the included papers. A high level of blood loss is detrimental to the patient and can in extreme cases cause exsanguination and death.[82] Post-surgical bleeding is a significant challenge in patients with bleeding disorders such as haemophilia.[83] Blood loss can lead to the requirement for transfusion which carries a risk of complications such as immunologic reactions, immunosuppression, and infection transmission.[84]

A dressing that is used on a wound healing by primary intention may also be required to absorb sanguineous or haemoserous exudate in the immediate postoperative phase.[11] The level of wound exudate may be greater if surgical wounds are to heal by secondary intention.[85] If exudate is not managed well, then maceration of the wound and surrounding tissue can occur.[86] Maceration can break down skin barriers and allow entrance of pathogenic bacteria that can then proliferate in the wet and warm environment.[87-89] The development of wound dressings that can manage varying levels of exudate has been a cornerstone in the treatment of post-surgical wounds for several years.[90] Such dressings include foams,[55,91] hydrocolloids,[92,93] and superabsorbent polymer wound dressings.[94] It has been demonstrated that hydrofibre and hydrocolloid dressings have high absorptive capacity and permeability that can cope with exudate production.[95] These dressings may be changed less often and have low blistering rates, which may reduce SSI.[58] Fluid management-related issues were identified in 21 records during the scoping review.

Bleeding: Orthopaedic surgery was identified as being associated with high levels of blood loss[96,97] that can lead to extended hospital stays.[97] A variety of surgical dressings are available that can initiate haemostasis and prevent excessive bleeding. For example, both alginate[98] and chitosan-based wound dressings have been shown to be effective haemostats and useful in surgical procedures to prevent blood loss.[99] Chitosan has also been shown to be an effective antimicrobial and procoagulant and promotes wound healing.[80] Additionally, calcium alginate dressings with haemostatic properties may prove effective in management of sanguineous exudate produced by surgical wounds healing by secondary intention, in their early stages of healing.[100] The influence of wound dressings on the presence of seromas post-surgery when using compression bandaging[101] and surgical padding[102] highlight their usefulness as physical barriers to blood loss. Steenfos and Agren[98] highlight the benefit of an alginate dressing for absorbing early blood from split thickness skin graft donor sites.

Wound exudate: The barrier properties of wound dressings promote a moist environment as well as aiding in the prevention of microbial contamination of the wound bed.[103,104] The peri-wound adhesive properties of a dressing facilitate a seal which prevents a portal of entry for organisms or leakage of exudate.[9] A study comparing the use of a new polyurethane film surgical dressing with gauze and tape in the care of post-operative wounds assessed dressing performance as part of the clinical assessment.[53] Dressing performance included the dressings' ability to control or manage wound exudate and the film dressing was found to perform better compared with the use of gauze. Several studies where film dressings have been shown to perform well in terms of exudate management in several wound types,[105] including skin graft donor sites.[106,107]

Skin damage

Potential postoperative complications include changes in skin integrity, such as erythema, erosion, maceration, and blistering; the last of these being considered the most important. The incidence of blistering described for orthopaedic surgery varies from 6% to 24%.[43,108] Blistering consists of the separation of dermis and epidermis, caused by oedema and inflammation, which usually appear after the fifth or sixth day of surgery, leading to increased wound pain and risk of infection.[109] Blisters of the peri-wound skin are common, being caused by the adhesion of the wound dressing to the skin surrounding the wound being too "aggressive" and that, upon its removal, tissue damage may occur.[43,73] Alternatively, if the adhesive component of the dressing is not strong enough then the dressing will loosen from its position and the wound will be exposed. Blisters may cause clinical adverse event sequelae (e.g., delayed wound healing, restricted joint range of motion (ROM), muscle atrophy and increased risk of deep vein thrombosis (DVT)) resulting in a significant and deleterious impact upon patient-related outcomes.[39,73,78,110,111]

Skin damage was not heavily assessed in the studies identified in this review. A total of 17 studies related to aspects of skin damage. Skin damage and local peri-wound trauma such as blisters and/or skin sensitisation were identified as problems associated with the adhesive components of post-surgical wound dressings.[112] Ten records identified skin breakdown (including blistering) in this scoping review. Non-infectious complications (including blistering) were noted in a comparative study of post-surgical wound patients treated with a polyurethane film dressing or a gauze/tape combination.[53] In this study examining wounds of predominantly orthopaedic origin the gauze/tape group showed an 8.7% rate of blistering compared with only 2.3% in the film dressing group ($p=0.04$). Several additional studies examining the effectiveness of wound dressings (in many cases compared with conventional dressings) in treating wounds arising from hip or knee surgery showed skin blistering which was dependent upon the dressing used.[39,43,78,79,110]

Skin sensitization is a problem associated with the adhesive components of post-surgical wound dressings.[112] The peri-wound skin is subject to varying degrees of traumatic insult, either from sutures, staples, or the application of wound dressings, skin tapes or cleansing regimens.[113,114] Care of peri-wound skin can be challenging and further complicated by dermatitis associated infections, allergic contact dermatitis or irritant contact dermatitis.[115] Reactions to wound dressings or their components (e.g., adhesives) are not uncommon.[112,116,117] A consequence of skin sensitisation is that the damaged skin forms a portal of entry for organisms and may lead to cellulitis or systemic infection and prolonged healing may also result because of the dermatitis or infection.[116] Seven studies described skin irritation/dermatitis as study parameters. Complications such as dermatitis were reported in a number of studies including one randomised, interventional study comparing a papaya dressing with hydrogen peroxide solutions to promote debridement where both treatment arms reported adverse effects such as skin dermatitis.[66] In a study comparing the use of a polyurethane film dressing with a gauze/tape combination in patients with post-operative wounds, the rate of erythema in the gauze/tape group was significantly greater compared with the film dressing group (12.2% vs. 2.8%, $p<0.01$).[53]

Pain

It is important to note that inflicting trauma (e.g., blistering, skin stripping, sensitisation, and maceration) will also cause suffering and pain to the patient.[118] Surgical pain is pain that results from a surgical procedure and may be controlled by local anaesthesia or intraoperative analgesia.[119-121] It has several potential causes, including tissue damage at the incision site, the procedure itself, the method of closing of the wound (e.g., sutures, stables, or tissue adhesives) or at dressing changes when adherence causes tissue trauma and pain.[117] Pain can cause stress, delay healing, and increase the risk of infection.[122-124] Selecting the most appropriate dressings (e.g., silicone dressings that are atraumatic) to reduce such pain will reduce adverse consequences and can reduce the risk of infection.[125-127]

Thirty-one articles focused on the use of post-surgical wound dressings that provided a reduction in pain including antimicrobial dressings,[128,129] biological dressings,[130-132] and advanced dressings.[40,41,79,107,133,134]

CHALLENGES OF ALIGNING WOUND DRESSINGS FOR PREVENTION AND TREATMENT OF SSIS

The inappropriate use of antibiotics is associated with the development and spread of antibiotic-resistant bacteria through the selection of antibiotic-resistant strains[135-137] and there is a strong association between antibiotic prescribing and development of resistance:[136,138] in England, for example, more than 70% of antibiotics are prescribed in primary care, many of which are deemed inappropriate.[139] To aid in the control of antibiotic/antimicrobial resistance (AMR), antimicrobial stewardship interventions targeting antibiotic prescribing have been introduced.[140] However, the effect of these interventions upon actual AMR has been limited thus far.[141,142] Although interventions targeting antibiotic use can result in changes in resistance over a short period, they may be inefficient alone to curtail antimicrobial resistance.[143]

The Un General Assembly has identified AMR as a significant challenge globally in all healthcare arenas.[144] The six leading pathogens contributing to the burden of AMR in 2019 (*Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Streptococcus pneumoniae*, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*) have been identified as priority pathogens by WHO,[145] and a recent study provides a comprehensive estimate of AMR burden.[24]

Strategies to manage AMR, which include stewardship, are summarised in Table 4.

Lipsky et al[146] suggests that applying principles of AMS to the care of patients with wounds should help to reduce the unnecessary use of systemic or topical antibiotic therapy and ensure the safest and most clinically effective therapy for infected wounds.

Wound infection remains a significant problem in post-surgical wounds with several factors related to the attributes of post-surgical wound dressings that might interplay with SSI, either in the development or prevention of infection (if the dressings are used inappropriately/appropriately respectively). Although the main treatment option for SSIs lies in the use of systemic antibiotics, antimicrobial dressings are an important adjunct to the treatment of SSIs to be used in wounds that are locally infected.[147] However, using antimicrobial agents in an uncontrolled fashion does not align with the principles of AMS (Table 4) and will lead to increased antimicrobial resistance.

The role of AMS programmes in surgical care is important and presents several unique challenges, most notably in the perioperative setting where factors such as length of antibiotic prophylaxis are a contentious issue.[148] The appropriate usage of surgical antibiotic prophylaxis significantly reduces the risk of SSI.[18,149] A recent systematic review of the effectiveness of AMS in promoting adherence to surgical antibiotic prophylaxis protocols in hospital patients and the effect on SSI rates and cost-benefit ratios found that AMS indicated that there was evidence of reduced SSI rates and a positive economic impact.[150] Other systematic reviews suggest that the implementation of AMS programmes led to an overall decrease of antimicrobial consumption.[151,152]

Notably the use of antimicrobial wounds dressings as primary prevention of infection is likely to be beneficial in patients with surgical wounds at an increased risk of infection. In some cases, there may be the potential for the use of antimicrobial wound dressings as a replacement for antibiotic prophylaxis. However, as with all treatment of infection, the effect of antimicrobial dressings must be closely monitored and reassessed regularly, should the wound fail to respond or there is a further deterioration of the wound.

The application of AMS programmes to surgical wounds and the treatment of SSIs is an important subject but infection is one of the most important complications of, and drivers of nonhealing wounds.[153] A significant proportion of the data related to AMS and its use in wounds is related to surgical wounds and SSIs. In wound care, it is important that antimicrobial treatment – particularly antibiotic treatment – is appropriate to reduce infections, and AMS is an important tool in the fight to limit the development of bacteria resistant to antimicrobial agents.[154] The outpatient wound care centre features prominently in the development of antimicrobial resistance for several reasons including that a nonhealing wound can be open for several months and, in that time, the patient may receive repeated courses of antibiotics and topical antimicrobials, and uninfected wounds with excessive inflammation are often misdiagnosed and treated as infected.[155] Clinicians' reliance on clinical signs and symptoms (CSS) to assess infection at the point of care to inform prescription of antibiotics and other antimicrobials, despite evidence suggesting that CSS has poor sensitivity for detecting infection, is a central concern that hinders AMS efforts and results in the "haphazard" use of antimicrobials.[156] Improved methods of identifying bacterial burden and infection are needed to enhance antimicrobial stewardship efforts in wound care.[156]

Optimal management of wounds relies on the appropriate use of antimicrobial therapies when they are clinically indicated, to minimise the risk of adverse events.[157] There is limited advice on the application of AMS to non-antibiotic antimicrobials related to wounds[158,159] and guidance is largely centred on reducing the use of antibiotics for managing infections.[146] The potential of alternative antimicrobial strategies to minimize antibiotic usage has also been described.[160] Non-antibiotic antimicrobials used in wound care products include silver (including salts and nanoparticles), povidone-iodine, and cadexomer iodine. It is proposed that the use of non-medicated wound dressings is effective and can be aligned with AMS,[161] for example, DACC-coated dressings in preventing/treating wound infections[50] and alignment with AMS has been reported.[25] Lipsky et al[146] in a position paper highlights AMS as being central to wound care treatment and underlines the necessity for appropriate use of antimicrobials, improving patient outcomes, reducing microbial resistance, and decreasing the spread of infections caused by multidrug-resistant organisms but concludes that available evidence is limited.

A recent e-survey sought to explore wound care practitioners' opinions on AMS and treatment in wound care (which would include treatment of SSIs).[162] A majority of respondents (57.9%) were at least partly aware of AMS and almost all implemented strategies to reduce antimicrobial prescribing. Importantly, 36% of respondents took steps to measure the impact of AMS and over 35% reported positive impacts (e.g., cost reductions, reduction in the use of systemic and topical antimicrobials, reduction in the levels of antimicrobial-resistant microbes). Interestingly, over a third of respondents noted negative consequences of implementing AMS programmes. These included poorer clinical outcomes in terms of healing and increased costs.

It is imperative to raise the importance of alignment of prevention/treatment of SSIs with the considerations of AMS. The evidence identified in this review demonstrates that alternative ways (to the use of antimicrobial agents) for treating AMR in post-surgical wounds are available and should be examined in more detail with regards to their suitability for use to obtain better patient outcomes.

RECOMMENDATIONS

- Research to better understand the challenges for the use of wound dressings in the treatment of post-surgical wounds.
- Healthcare workers are extra cautious when considering the challenges of treating post-surgical wounds healing by primary intention with dressings, and how these challenges relate to the development of SSIs.
- Consider the challenges of preventing and treating infection in post-surgical wounds.
- Staff training and education is promoted to improve practitioner knowledge and practices of wound dressing use for the prevention or treatment of wound infection in post-surgical wounds aligned with AMS positioning.

LIMITATIONS

Despite identifying a significant number of studies, it is acknowledged that the literature search for this review may not have captured all relevant publications. The review also recognises the limitation of not having published the scoping review protocol before conducting the study, which prevented peer review and critical appraisal of publication quality. Also, the decision to only include studies published in English could have created a potential for language bias, and it is acknowledged that this review does not include this potential body of studies.

CONCLUSIONS

This scoping review has highlighted several unique challenges and some areas that require further investigation to obtain better clinical outcomes. Of particular importance is the evidence demonstrates the impact of SSIs is still significant, and the development of AMR has exacerbated the situation. It is imperative that prevention and treatment (specifically using appropriate antimicrobial dressings) of SSIs should be aligned with AMS programmes. The development of wound dressings that have alternative (physical) antimicrobial effects should be investigated further.

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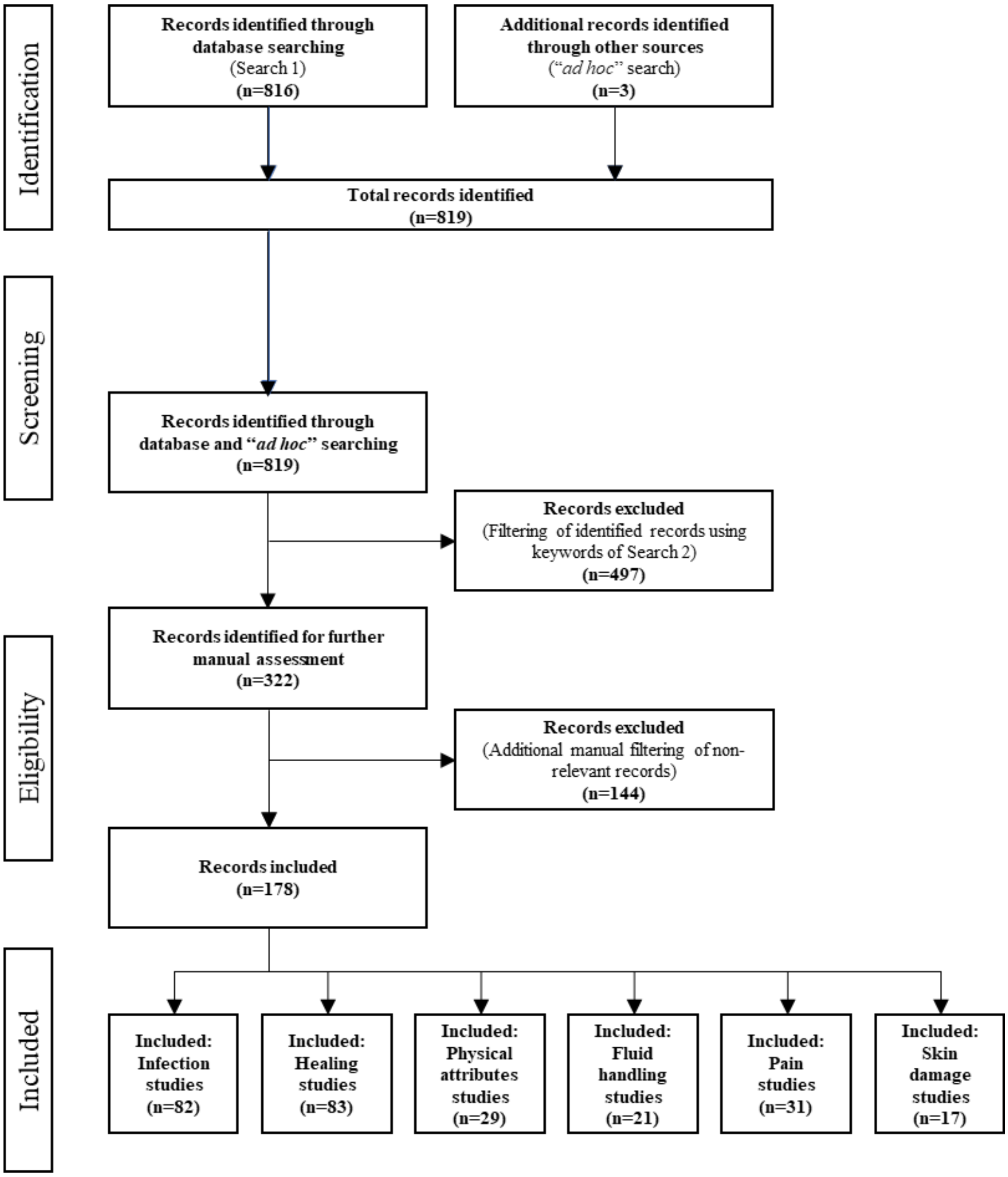

Fig. 1 Flow chart showing the number of studies identified and eligible for scoping review inclusion

Table 1. Search strategy summary	
Items	**Specification**
Date of search (specified to date, month, and year)	Jan-2021
Databases and other sources searched	PubMed/MEDLINE database
Search terms used (including any MeSH and free text search terms and filters)	See Table ??
Timeframe	Jan-1954 to Dec-2020
Inclusion and exclusion criteria (study type, language restrictions, etc.)	Papers written in English related to the post-surgical wounds including split thickness donor sites and laser resurfacing studies were included. Any papers not written in English were excluded. Non-clinical studies were excluded. Review, commentary, protocol, and guideline papers were excluded. Papers with no abstract available were also excluded
Selection process (who conducted the selection, whether it was conducted independently, how consensus was obtained, etc.	The selection process was done independently by Mark G. Rippon and Alan A. Rogers
Any additional considerations, if applicable	No additional considerations

Table 2. Search strategies	
Searches	Search strategy
Search 1	("post"[All Fields] AND ("surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "surgical"[All Fields] OR "surgically"[All Fields] OR "surgicals"[All Fields]) AND ("injuries"[MeSH Subheading] OR "injuries"[All Fields] OR "wounds"[All Fields] OR "wounds and injuries"[MeSH Terms] OR ("wounds"[All Fields] AND "injuries"[All Fields]) OR "wounds and injuries"[All Fields] OR "wound s"[All Fields] OR "wounded"[All Fields] OR "wounding"[All Fields] OR "woundings"[All Fields] OR "wound"[All Fields]) AND ("bandages"[MeSH Terms] OR "bandages"[All Fields] OR "dressing"[All Fields] OR "dressings"[All Fields] OR "dressed"[All Fields] OR "dresses"[All Fields] OR "dressing s"[All Fields] OR "drug hypersensitivity syndrome"[MeSH Terms] OR ("drug"[All Fields] AND "hypersensitivity"[All Fields] AND "syndrome"[All Fields]) OR "drug hypersensitivity syndrome"[All Fields] OR "dress"[All Fields])) AND (1954/1/1:2021/12/31[pdat])
Search 2	“NOT ("negative"[All Fields] OR "negatively"[All Fields] OR "negatives"[All Fields] OR "negativities"[All Fields] OR "negativity"[All Fields])) NOT ("pressure"[MeSH Terms] OR "pressure"[All Fields] OR "pressures"[All Fields] OR "pressure s"[All Fields] OR "pressurisation"[All Fields] OR "pressurised"[All Fields] OR "pressuriser"[All Fields] OR "pressurization"[All Fields] OR "pressurizations"[All Fields] OR "pressurize"[All Fields] OR "pressurized"[All Fields] OR "pressurizer"[All Fields] OR "pressurizes"[All Fields] OR "pressurizing"[All Fields])) NOT ("vacuum"[MeSH Terms] OR "vacuum"[All Fields] OR "vacuums"[All Fields] OR "vacuumed"[All Fields] OR "vacuuming"[All Fields])) NOT ("chronic"[All Fields] OR "chronical"[All Fields] OR "chronically"[All Fields] OR "chronicities"[All Fields] OR "chronicity"[All Fields] OR "chronicization"[All Fields] OR "chronics"[All Fields])) NOT ("periodontal"[All Fields] OR "periodontally"[All Fields] OR "periodontically"[All Fields] OR "periodontics"[MeSH Terms] OR "periodontics"[All Fields] OR "periodontic"[All Fields] OR "periodontitis"[MeSH Terms] OR "periodontitis"[All Fields] OR "periodontitides"[All Fields])) NOT ("burning"[All Fields] OR "burns"[MeSH Terms] OR "burns"[All Fields] OR "burned"[All Fields] OR "burnings"[All Fields])) NOT ("bone and bones"[MeSH Terms] OR ("bone"[All Fields] AND "bones"[All Fields]) OR "bone and bones"[All Fields] OR "bone"[All Fields])”

Table 3. Dressings involved in promoting healing progression	
Class of dressings	Examples
Biological	Epidermal/dermal grafts[163,164] Human skin equivalents[165] Autologous epithelium and micro-grafts[67,166,167] Amniotic membranes[168,169] Human microbiota[170] Porcine ECM[130] Platelet gels and platelet-rich plasma[132,171] Haemoglobin spray[172] Chitosan[80] Egg membranes[173] Matrix dressings[174]
Advanced	Hydrofibre and hydrocolloids[58,175,176] Hydrogels[177] Film dressings[41,53] Alginate dressings[178] Silicone dressings[134,179] Laser therapy[180] Skin bonding adhesives[181] Miscellaneous[40,52,81,182]
Bioactive	β-N-oxalyl-L-α,β-diaminopropionic acid[183] Growth factors[184]
Antimicrobial	Antiseptics[185,186] Antibiotics[187] Silver dressings[38,188,189] Microbiota[170]
Plant-based	Qiyu oil gauze[190] Sphagnum moss[191] Papaya[66]

Table 4. Tackling antimicrobial resistance on ten fronts[192]
1. Increased public awareness 2. Better sanitation and hygiene 3. Reducing antibiotic use in agriculture and the environment 4. Using vaccines and alternatives (to antimicrobials) where appropriate 5. Rapid diagnostics 6. Increased surveillance of infections 7. Human capital 8. Drugs 9. Global Innovation fund 10. International coalition for action