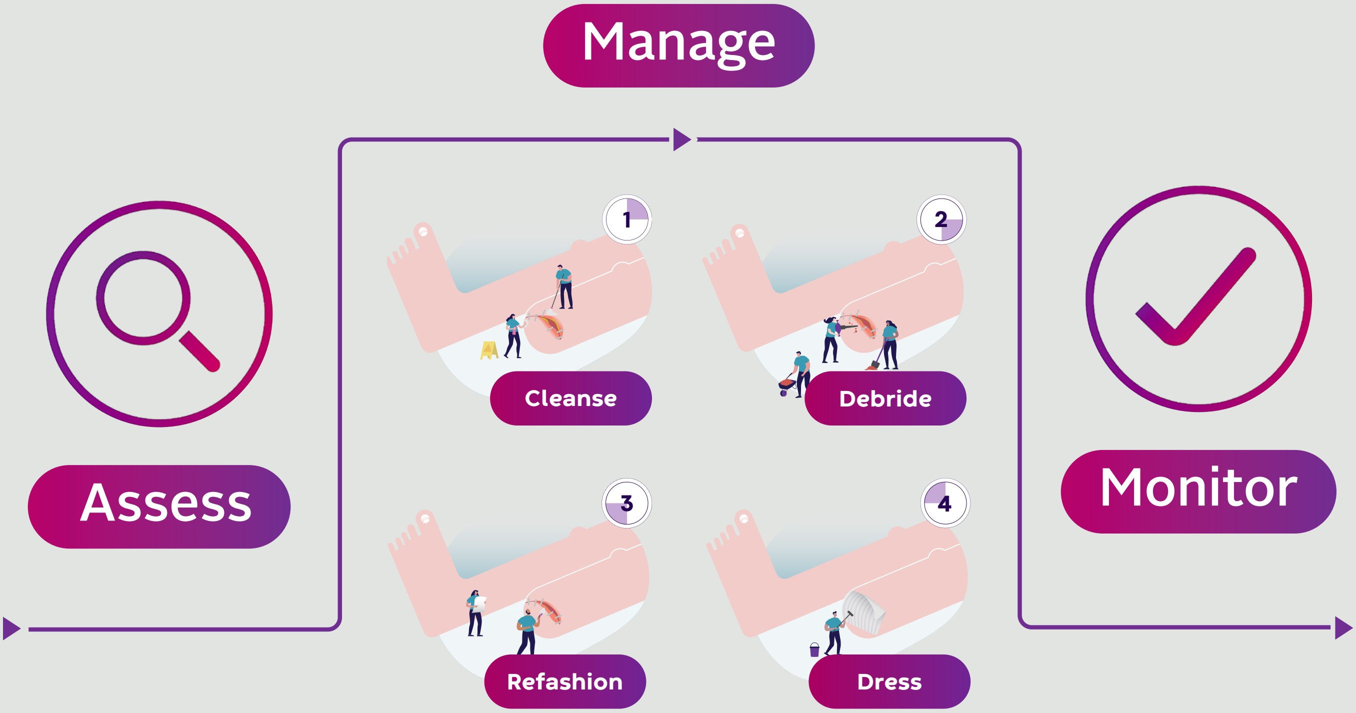
JWC International Consensus Document

A proactive healing strategy for tackling biofilm-based surgical site complications: **Wound Hygiene Surgical**



Wound Hygiene

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Panel chair Chris Murphy

Introduction

The wounds created during surgical operations do not always heal as expected, and many develop complications. The most common surgical complication is surgical site infection (SSI), which can delay healing and lead to further complications, with negative impacts on clinical outcomes, patient wellbeing and treatment costs. Recent research has linked impaired wound healing to the development of biofilm – microbial communities that are present in all wounds, resist antimicrobial treatment and cause persistent local infection. Moreover, the great majority of SSIs are the result the presence of biofilm-forming bacteria. Consequently, it can be reasoned that biofilms are a major contributor to surgical wound complications and thus impose a heavy burden on health systems and healthcare professionals, as well as on patients and their families.

The role of biofilm in surgical wound complications was the subject of an international consensus meeting convened in the summer of 2023. The surgeons and specialist nurses who comprised the multidisciplinary expert panel drew on their professional clinical experience and the latest evidence to identify the key issues and offer guidance on managing biofilm to prevent and resolve surgical wound complications. This consensus document presents the outcomes of that discussion.

- The first section describes the healing process for surgical wounds and how this can be disrupted by complications including SSI and dehiscence. It then presents the evidence on the prevalence and impact of SSIs, as well as the role of biofilm in impaired wound healing. This leads to the conclusion that biofilm must be present in all surgical wounds, as well as implicated in surgical wound complications, and thus there is a need for a proactive antibiofilm approach to perioperative care.
- The second section introduces Wound Hygiene, an antibiofilm protocol of care introduced in a 2020 international consensus document and now already established outside the surgical arena.[1,2] The four key steps of Wound Hygiene are summarised, along with its evolution and integration into a proactive healing strategy within a holistic framework.[1,2] This section concludes that, as Wound Hygiene is applicable across a range of clinical competencies and specialisms, it is applicable for expansion into perioperative wound care.
- The third section introduces Wound Hygiene Surgical as an adapted protocol of care for local management of all surgical incisions. It presents the consensus panel's recommendations on how the four-step protocol (cleanse, debride, refashion and dress) should be applied in a surgical context, depending on whether the wound is closed or open and healing by primary, secondary or tertiary intention.
- The fourth section outlines how Wound Hygiene Surgical should be implemented within a holistic framework as part of a proactive perioperative healing strategy. The consensus panel's recommendations cover preoperative assessment, as well as intraoperative and ongoing postoperative monitoring, alongside holistic patient management throughout the perioperative period. It emphasises how Wound Hygiene Surgical should complement, rather than replace, existing local, national and international guidance on best practice in perioperative care. Likewise, implementation of these recommendations must be based on independent judgement and consideration of the individual patient's clinical circumstances.

The consensus document concludes with a call to action for specialists in wound management and surgical care to break down barriers between these two disciplines. This will raise the awareness of biofilm, its implications and its management, which is crucial to improving surgical wound care.

It is hoped that implementation of Wound Hygiene Surgical will help reduce the incidence of surgical wound complications, including SSI and dehiscence. This should improve clinical outcomes and overall wellbeing for surgical patients, as well as help lift some of the health-economic burden of surgical wound complications.

Section 1. Understanding surgical wound healing

Each year, over 310 million surgeries are performed worldwide, with 40–50 million of those performed in the United States and around 20 million in Europe.[3] An estimated 1–4% of these patients die, up to 15% have serious postoperative morbidity and 5–15% are readmitted within 30 days.[3] SSIs are a leading cause of this postoperative morbidity and mortality. In addition, SSIs pose significant health-economic repercussions, as well as a quality-of-life burden for the people they affect (*Figure 1*).

> **Consensus statement:** Understanding SSIs and undertaking new approaches to prevent and manage them are critical for healthcare systems and healthcare professionals to improve the results of surgery.

Trajectories of healing

Surgical wounds normally progress along an expected trajectory of healing (*Figures 2* and *3*).[4]

A normal surgical wound will initially present as erythematous (beefy red in colour), with mild erythema to the periwound skin. The colour will change to bright pink over the second week after surgery, before progressing to pale pink. The colour will eventually settle as either white or silver in lighter-skinned patients or a darker-than-usual colour (hyperpigmented) in patients with darkly pigmented skin.[4]

Ideally, the edges of a surgical wound should fit neatly together (well approximated). The wound edges should then achieve epithelial closure by around day 4. For the next few days, approximately days 5–9, a healing ridge of thickened tissue should develop as part of the fascial

Figure 1. Impact of surgical site infections[3]

Of 310 million annual surgeries worldwide
- 15% have serious postoperative morbidity
- 5–15% are readmitted within 30 days
- 1–4% die

SSIs are a leading cause of postoperative morbidity and mortality
- Responsible for 1/5 of healthcare-acquired infections
- Cause of up to 1/4 of infections after surgery
- Behind 1/3 of postoperative deaths

SSIs can lead to further complications
- Slowed, stalled or reversed wound healing, with risk of dehiscence
- Local cellulitis, abscess formation or osteomyelitis
- Systemic sepsis or bacteraemia

SSIs seriously harm patient wellbeing and quality of life
- Lost productivity and incomes
- Temporary or permanent decline in functional or mental capacity
- Negative perceptions of professional–patient relationship

SSIs place a considerable burden on healthcare systems
- 3× or 4× cost of surgical procedures
- $400–$30,000 cost per infection
- >33% antibiotic resistance

Figure 2. Normal healing trajectory for a surgical wound

Figure 3. Trajectories of healing for a surgical wound[4]

Normal healing		Impaired healing
• Colour change from red to bright pink and then to pale pink • Resolution as white/silver (lighter skin) or darker than usual (darker skin)	**Wound colour**	• Enhanced and persistent redness • Lack of complete epithelial resurfacing
• Neatly opposed edges • Epithelial closure around day 4 • Epithelial ridge developed over days 5–9	**Wound edges**	• Areas of separation and dehiscence • Tension in incision line and potential scarring and contracture
• Progression to serosanguineous and serous exudate • Steady reduction in volume and resolution within the first week	**Exudate**	• Persistently sanguineous or serosanguineous exudate • Purulence • Persistence beyond week 1
• Initial presence of inflammation, depending on site and operation • Mild severity • Resolution within the first week • Indicative of inflammatory healing processes	**Signs of inflammation** redness, swelling, heat and pain	• Initial absence of inflammation for the first few days • Enhanced severity • Persistence beyond the first week • Indicative of potential infection

layers knitting themselves back together, indicating newly formed collagen.[4]

Exudate from a surgical wound will normally transition from sanguineous (primarily blood) to serosanguineous (some blood) and then serous (clear/amber serum). The exudate should also decrease in volume until it resolves over the first 5 days.[4]

The normal healing process for surgical wounds is inflammatory-mediated, and thus it may present with signs of inflammation such as redness (erythema/rubor), swelling (tumor/oedema), heat (calor) and pain (dolor). Pain will vary in degree and duration depending on the surgical site and surgery type, but it normally resolves by the end of week 1. These signs are typically mild and acute, resolving by around postoperative day 5, and so may be distinguished from the more severe and persistent signs of inflammation indicative of developing infection.[4]

Surgical wounds do not always progress along the expected healing trajectory. Surgical wounds with impaired healing can remain erythematous (red) beyond the expected period. There may be tension in the incision line and areas of separation in the wound edges. Epithelial resurfacing may remain incomplete, with a lack of a healing ridge. Exudate can persist or increase in level, as well as remain serosanguineous or serous. The exudate may become purulent, with a cloudy green, yellow or brown appearance and offensive odour. Somewhat counterintuitively, signs of inflammation may be absent in the first few days after surgery. Once these signs begin to present, they may be prolonged and difficult to resolve, especially pain.[4]

Healing can be impaired by a wide variety of complicating incidents, from minor to very serious. Some common examples include the following:

- Bacteraemia
- Bleeding
- Dehiscence
- Haematoma
- Herniation
- Hypergranulation
- Medical adhesive-related skin injury (MARSI)

- Periwound maceration
- Scarring/contracture
- Seroma

However, the most common surgical wound complication is infection.

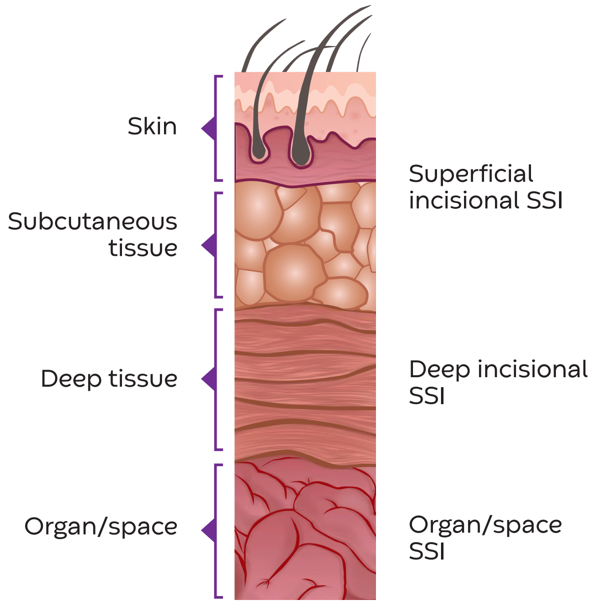
Surgical site infections

Definition

An SSI can be clinically defined as an infectious process present at the site of surgery (further definitions are given in *Appendix 1*).[5] SSIs should be classified according to the standardised, internationally validated and widely accepted criteria provide by the US Centers for Disease Control and Prevention (CDC).[5] Classification of SSIs is important for accurate reporting, surveillance and benchmarking of trends across healthcare settings. The CDC criteria classify SSIs into three types according to the depth of infection and time of onset (*Figure 4*):[5]

- Superficial incisional SSIs, where infection involves only the skin and subcutaneous tissues, occurs within 30 days of the procedure and has at least one of the signs and symptoms in *Box 1*
- Deep incisional SSIs, where infection is present in deeper soft tissues, such as muscle and fascial planes, typically with evidence of abscess formation, occurs within 30 or 90 days (if an implant is present) of the surgical procedure and has at least one of the signs and symptoms in *Box 1*
- Organ/space SSIs, where infection spreads to any organ as a result of a surgical procedure, occurs within 30 or 90 days (if an implant is present) and has at least one of the signs and symptoms in *Box 1*.

Figure 4. Types of surgical site infection[6]



SSI=surgical site infection

Surgical wounds that are surgically opened or re-opened for cleaning should also be considered and documented as an SSI.[6] However, a wound should not be considered an SSI because of the development of a suture-related abscess.[6] Although exact prevalence figures vary, evidence suggests that the majority of all SSIs are superficial incisional SSIs.[6]

Box 1. Signs and symptoms for depth classification of surgical site infection (SSI)

Superficial incisional SSIs
- Increased pain and tenderness at surgical site
- Localised swelling and induration
- Localised heat and redness of the wound
- Purulent drainage
- Cellulitis limited to wound and adjacent tissues
- Evident superficial wound abscess

Deep incisional SSIs
- Increased pain at the site of surgery
- Spreading induration and swelling of site
- Erythema and heat of the surgical site
- Purulent drainage from the incision
- Spreading cellulitis at the site of surgery
- Evident deep wound abscess or fasciitis
- Separation of edges exposing deeper tissues
- Unexpected postoperative fever, accompanied by increasing wound pain and/or dehiscence
- Pathological blood test findings*

Organ/space SSIs

Involving any part of the anatomy other than the incision opened or manipulated during surgery
- Purulent drainage from a drain placed through the skin into the organ or body space
- Organ or body-space abscess diagnosed by radiological or histopathological examination
- Evidence of infection involving the organ or body space seen on direct examination during surgery
- Postoperative fever
- Positive blood cultures, deep-tissue biopsies, surgical sampling or pathological blood findings*

*Elevated C-reactive protein, white blood count, erythrocyte sedimentation rates and pro-calcitonin

Incidence

The CDC estimated that SSIs account for around one-fifth of healthcare-acquired infections (HAIs) and 20–25% of HAIs in surgical patients, making it the leading cause of HAI alongside pneumonia.[7–9] The European Centre for Disease Surveillance and Control (ECDC) estimated that SSIs contribute to 18% of HAIs.[10,11] The World Health Organization (WHO) has an even higher estimate, suggesting that up to one-third of people who undergo surgery worldwide may develop an SSI, with the highest rates in low- and middle-income countries.[12,13] Furthermore, the GlobalSurg Collaborative found that SSIs were implicated in one-third of postoperative deaths and accounted for 8% of all deaths caused by HAIs.[14]

Consensus statement: There is limited evidence regarding the pooled global and regional incidence of SSIs, primarily as a result of a lack of homogeneous data collection. Therefore, SSIs are likely to be under-reported in the literature, and there may be a large hidden impact beyond what is currently known.

Clinical impact

SSIs are associated with further complications (*Figure 5*). Healing may be slowed, stalled or reversed. As an infected surgical wound breaks down because of impaired healing, the previously approximated wound edges can partially or totally separate (dehisce). Dehiscence may or may not be indicative of an underlying infection. Infection-related surgical wound dehiscence (hereafter simply 'dehiscence') can also be caused by poor surgical or suture technique or a suboptimal choice of postoperative dressing.[15]

Other local SSI-related complications include cellulitis, abscess formation and osteomyelitis. Systemic complications include sepsis and bacteraemia, which can be spread via the bloodstream (haematogenous). Haematogenous spread should be considered as its own category of surgical wound complication, rather than an SSI.[6]

Consensus statement: The epidemiology of SSIs demonstrates that they are a key issue across the spectrum of perioperative care.

Health system and economic impact

By increasing treatment times, lengths of stay and readmissions, SSIs take up the time and focus of healthcare staff and displace healthcare resources from other priorities.[16,17] This can lead to delays in treatment for the patient, particularly adjunctive treatment for chronic or acute conditions and rehabilitative treatments relating to surgery, which broaden the potential for worsened surgical outcomes, as well as disease progression.[17–19]

Figure 5. Surgical wound complications

SSIs have a significant impact on costs of healthcare. The cost of overall treatment related to a surgical procedure can triple or even quadruple because of an SSI.[16,20] However, the estimated cost of managing an SSI increases depending on the depth of infection, ranging from approximately $400 for a superficial incisional SSI to more than $30 000 per organ/space SSI.[19] A review comparing 15 low- and middle-income countries with 16 European countries found that costs ranged from $174 to $29 610 in the former, and from $21 to $34 000 in the latter.[13] Globally, the total cost of SSIs reaches into the billions of dollars.[21]

Besides the broader costs of reduced patient quality of life, the economic impact of SSIs is attributable to several direct cost increases:

- Longer hospital stays
- Readmissions
- Outpatient and emergency visits
- Further/repeat surgeries

- Prolonged antibiotic treatment
- Additional diagnostics, such as radiological procedures and laboratory tests
- Home health visits
- Other ancillary services, medicines and professional fees.[18]

Increased use of antibiotics not only has a cost impact, but it can also contribute to the rise of antibiotic resistance. Rates of antibiotic resistance in patients with an SSI can exceed one-third. Therefore, antimicrobial stewardship has serious implications for reducing the risk of both SSIs and antibiotic resistance.[22]

Consensus statement: Given the evidence throughout the literature, as well as the lived professional experience of the panel members, SSIs should be viewed as a 'silent epidemic', characterised by gaps in communication and continuity of wound care, with serious implications for health service provision and resource use, as well as quality of life and health levels of surgical patients.

Table 1. Risk factor comparison[6,21,23–29]

Risk factor	HHW	SSI
Psychological stressors		✔
Smoking	✔	✔
Inappropriate alcohol consumption	✔	✔
History of intravenous drug use	✔	
Poor diet, nutrition or glucose control	✔	✔
Poor hydration status	✔	✔
Hiding wounds or DIY dressings		✔
Body type (obese or underweight)	✔	✔
Diabetes mellitus	✔	✔
Cardiovascular disease	✔	✔
Immunosuppression	✔	✔
Cancer		✔
Laboratory values	✔	✔
Immobility/lack of dexterity		✔
Neuropathy		✔
Systemic infection or osteomyelitis		✔
Coexistent infection at a remote site	✔	
Advanced age (≥65 years)	✔	✔
Immune/autoimmune disorders		✔
Genetic conditions		✔

HHW=hard-to-heal wound; SSI=surgical site infection

Quality-of-life impact

There is literature on the impact of SSIs on patient wellbeing and impact on quality of life. One guideline review found that effects include lost productivity of the patient and carers, as well as a temporary or permanent decline in functional or mental capacity.[19] In addition, a systematic review found that patients with an SSI experienced negative impacts across the physical, psychological, social, spiritual and economic aspects of their lives.[22] Notably, adult patients were found to experience a low quality of life, with particular limitations in physical, social and psychological functioning, including a negative perception of the clinician–patient relationship.

Surgical site infections as hard-to-heal wounds

The preoperative risk factors for developing surgical wound complications, including SSIs and dehiscence, overlap closely with the risk factors for developing a hard-to-heal wound. This suggests that wounds of different origins share similar potential causes of deterioration and barriers to healing (*Table 1* and *Box 2*).[6,21,23–29]

Consensus statement: SSIs and dehiscence should be considered types of hard-to-heal wound. Surgical wounds that do not heal as expected should be termed 'hard-to-heal' instead of 'chronic'.

Box 2. Biofilm and hard-to-heal wounds

A hard-to-heal wound is a wound that has failed to respond as expected to evidence-based standard of care. A hard-to-heal wound can be a wound of any origin, type and aetiology, including both simple and complex wounds. Because of the speed with which wound biofilm forms, a wound can be characterised as having failed to respond either because it has not improved in an expected timeframe or because it has deteriorated (e.g., exudate, slough and an increase in size by day 3). Hard-to-heal wounds can regress, and so they should be treated as hard-to-heal until closure (instead of losing the hard-to-heal designation when they show signs of healing). All hard-to-heal wounds should be considered to contain biofilm.

The 2020 and 2022 consensus documents on Wound Hygiene recommended referring to these wounds as 'hard-to-heal wounds' rather than the older term 'chronic wounds'. This is because these wounds should not be considered impossible to heal, and a proactive approach should be undertaken to overcome the barriers to healing, such as presence of biofilm.[1,2]

Role of biofilm in surgical site infections

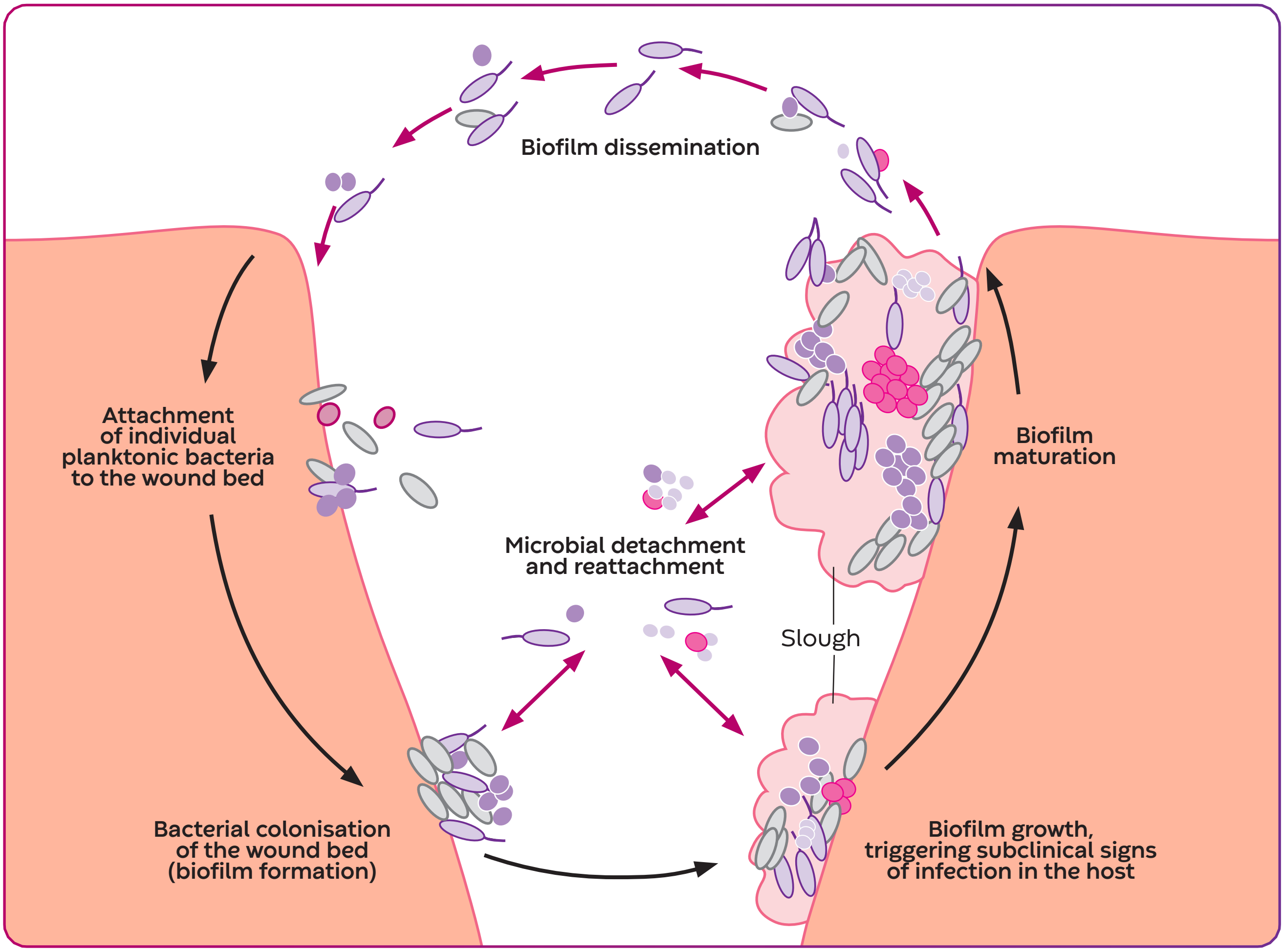
Wound biofilm (*Figure 6*) is a complex community of different microbial species of bacteria and fungi that causes a sustained subclinical wound infection and impairs wound healing.[30–33] Biofilm is invisible to the naked eye, but it presents with both covert and overt signs of local wound infection.[34] Biofilm protects itself from the host's immune response; reforms quickly when disturbed; and is resistant to antimicrobials, antibiotics and antiseptics.[34] Biofilm should be differentiated from acute infection, which results from the action of planktonic bacteria and can generally be treated with antibiotics.[35,36]

Biofilm is formed when planktonic bacteria attach to the wound surface. Biofilm can form within hours and reach maturity in 48–72 hours or sooner, at which point it can elicit a sustained but ineffective inflammatory response, depending on the strength of internal host defences and external factors.[37] Mature biofilm also seeds more planktonic bacteria, which can in turn transition to a new community of biofilm.[30]

Research clearly demonstrates that all wounds are colonised by biofilm to some degree. A selection of this research into wound biofilm is presented in *Appendix 2*. Biofilm is inconsistently distributed across and within the wound, and it is located primarily on the wound surface (although it can appear in deeper tissue). The extent and maturity of biofilm correlates to wound tissue type, and it is more likely to be harboured in non-viable tissue types, such as slough and necrotic tissue, than it is in healthy granulation tissue and epithelial tissue.[2,38–41]

In terms of the overall impact of biofilms, the National Institutes of Health have proposed that 80% of all known human infections are associated with biofilms, and the CDC has linked biofilms to over 65% of all hospital-acquired infections.[30] The literature shows that the

Figure 6. Stages of biofilm formation and maturity[2,32]



majority of SSIs are the result of the microbial burden that typically inhabits the skin, mucous membranes, anatomical cavities or cavities within organs and can form biofilms.[6] One review found that around 70–95% of all SSIs arise from the inherently present, potentially biofilm-forming microbiome of patients' skin or nares.[42] Another review reported that 80% of SSIs are the result the presence of biofilm-forming bacteria.[43] Furthermore, bacterial biofilms residing on implanted foreign bodies have been implicated as key contributing or causative factors for SSIs.[44,45]

Consensus statement: In surgical wound complications and other, non-surgical types of hard-to-heal wound, biofilm is a major causative factor, a ubiquitous presence and the primary barrier to healing. Consequently, antibiofilm approaches already established in non-surgical wound types should also be relevant and applicable to surgical incisions to reduce the risk and burden of SSI and dehiscence. Although these wound types have different origins and triggers for poor healing, the fundamental cause of hard-to-heal status is the same: biofilm. Consequently, policies that promote an antibiofilm approach to surgical wound healing have the potential to result in better healing rates and times; fewer antibiotic prescriptions; improved quality of life and wellbeing for patients; and significant cost savings for buyers and purchasers.

Consensus statement: Biofilm in surgical wounds

Bacteria and other flora are omnipresent on the human body, and they preferentially form biofilm in wounds. Therefore, it can be reasoned that biofilm is present in all wounds, including surgical incisions. This includes not only dehisced or open surgical wounds, where slough is a visible indicator of biofilm, but also closed incisions, as biofilm can migrate from the wound edges, regardless of whether these have been properly closed.

The presence of biofilm in surgical wounds has several significant implications:

- Biofilm in surgical wounds potentially leads to inflammation and infection or re-infection, which is associated with barriers to wound healing
- Surgical complications including SSIs and dehiscence are highly likely to be associated with biofilm
- Surgical complications and delayed healing can increase the length of hospital stay and have a negative impact on patient experience
- Resulting longer admissions and greater care requirements are also likely to increase costs to the patient and healthcare system
- Extended or repeated admissions, as well as medical care focused on the surgical site and/or perioperative recovery, can also delay initiation of adjunctive treatments, such as chemotherapy, with a negative impact on health outcomes[26,77]
- The development of SSIs can increase the need for antibiotics, with implications for antimicrobial resistance, considered a major global threat to human health[48]
- Ultimately, these factors can lead to surgical failure.

These clinical, economic and human burdens can be reduced with an antibiofilm approach to the prevention and management of hard-to-heal surgical wounds. This proposition is further backed by extrapolating what is known about biofilm in hard-to-heal wounds, and the implications of biofilm for general wound management should equally be applied to surgical wounds.

A targeted strategy that seeks to eradicate biofilm can minimise the risk of SSIs and dehiscence, as well as help resolve complications that do occur. Thus, early and proactive implementation of an antibiofilm strategy across the continuum of perioperative care has the potential to improve patient outcomes and so change the course of the silent epidemic of SSIs.

Section 2. Revisiting Wound Hygiene

This section summarises the established Wound Hygiene protocol of care, including how it has been subsequently expanded into a proactive healing strategy with a holistic framework. This summary is accompanied by the consensus panel's statements on the potential applicability of existing aspects of the framework to the surgical setting.

Protocol of care

Wound Hygiene is an established antibiofilm protocol of care first introduced in an international consensus document published in 2020.[1] The basic protocol comprises four key steps – cleanse, debride, refashion and dress (*Figure 7*). Each step in this proactive, structured approach aims to uproot biofilm as the major underlying cause of wounds that fail to heal. This makes Wound Hygiene a powerful toolkit that can overcome the barriers to posed by biofilm and thus aid wound healing. These steps should be carried out regularly and repetitively, and are performed in sequence at every dressing change, where appropriate.

> **Consensus statement:** The Wound Hygiene protocol of care is applicable to surgical wounds.

Wound Hygiene recommends that these steps are carried out in way that is appropriate to the tissue types visible on the wound bed. More intensive intervention is required for sloughy tissue, necrotic tissue and unhealthy granulation tissue, which are likely to harbour more biofilm than viable granulation tissue and epithelial tissue (*Figure 8*). Irrespective of tissue types present, the Wound Hygiene protocol should be implemented repeatedly until healing.[2] Further recommendations regarding the appropriate intensity of the individual protocol steps are given on pages S10–S11 of the 2022 Wound Hygiene consensus document.[2]

The 2022 consensus document on Wound Hygiene introduced a distinction between healthy and unhealthy granulation tissue.[2] A wound with unhealthy granulation tissue may not necessarily appear outwardly unhealthy; instead, it is defined by the presence of granulation tissue and failure to progress. Unhealthy granulation is typically dark red in colour (although it may sometimes present as pale when there is a poor blood supply), and it often bleeds on contact (friable) and may indicate the presence of wound infection. Unhealthy granulation can result from a number of factors, including ischaemia, untreated pathology and biofilm. Unhealthy granulation arises from a destructive inflammatory response to biofilm, rather than an acute infection status. It is analogous to gingivitis (a dental issue arising in part from the presence of biofilm). Emerging literature proposes differentiating this stage from typical (healthy) granulation tissue by giving it the name granulitis.[49] Healthy granulation tissue that extends above the level of the surrounding skin is known as hypergranulation and is the result of abnormal wound-bed conditions, such as granuloma or subclinical infection.

Figure 7. The four steps of Wound Hygiene[2]

STEP ONE

Cleanse

The wound bed and periwound skin are cleansed to remove non-viable tissue, debris and biofilm from the wound, helping prevent bacterial recolonisation originating from the wound bed or skin

STEP TWO

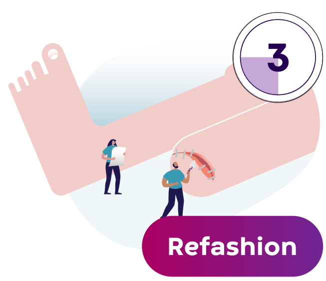
Debride

An active method of debridement is carried out, with sufficient vigour to provoke pinpoint bleeding, to remove any non-viable tissue and debris and optimise the wound bed to move towards healing

STEP THREE

Refashion

The wound edges are refashioned, with a method determined by wound assessment and clinician skill level, to remove necrotic, crusty and/or overhanging wound edges, which can harbour biofilm, and ensure the skin edges align with the wound bed



STEP FOUR

Dress

The wound is dressed based on its appearance, duration of care and healing response; antimicrobial or antibiofilm dressings can be considered to address residual biofilm while preventing or delaying biofilm regrowth between dressing changes.

Figure 8. Tissue types

Non-viable tissue

Necrotic
- **Appearance:** Dry, hard or leathery in texture and black, brown or grey in colour
- **Process:** Cell death usually from lack of blood supply (ischaemia) but sometimes from infection

Sloughy
- **Appearance:** Moist, soft, stringy and mucinous in texture and yellow, white or green in colour
- **Process:** Cell death during the inflammatory process

Unhealthy granulation
- **Appearance:** Dark red in colour, potentially non-responsive, prone to bleeding or malodour
- **Process:** Destructive inflammatory response to biofilm (not acute infection)

Viable tissue

Healthy granulation
- **Appearance:** Moist, shiny and cobblestone-like texture and bright red colour
- **Process:** Formation or growth of small blood vessels and connective tissue before epithelialisation

Epithelial
- **Appearance:** Pink or white in colour
- **Process:** Growth of new skin cells, closing the wound and restoring barrier function

Figure 9. Holistic framework for the Wound Hygiene proactive healing strategy[2]

Assess

Comprehensive patient and wound assessment focused on the aetiology

At dressing change, identify tissue types before performing the four steps and repeat until healed

Manage

Four key steps of Wound Hygiene based on tissue types, taking a proactive approach

Monitor

Ongoing monitoring focused on patient wellbeing and outcomes

After dressing change, identify specific treatment and adjunct therapies

Holistic framework

Wound Hygiene was reinforced by a further international consensus document, published in 2022.[2] This second consensus provided further practical instruction and guidance on integrating the protocol of care into a wider holistic framework as part of a proactive healing strategy.

Box 3. Implementation of Wound Hygiene Surgical by clinical competency[1,2]

Unregistered practitioner/little or no training in wound care
(e.g., healthcare assistant, carer)

- Cleanse the wound bed and periwound skin
- Debride the wound bed and periwound skin with a soft debridement pad or gauze
- Refashion the wound edges with a soft debridement pad or gauze
- Assess for signs of infection
- Apply a wound dressing
- Refer the patient to an advanced/registered practitioner

Registered practitioner/some training in wound care
(e.g., surgical nurse, postoperative nurse, surgical ward nurse or podiatrist)

- Holistically assess the patient, wound (including vascular supply and infection status) and environment
- Select and perform an appropriate method of debridement within individual scope of practice
- Apply larval debridement
- Refashion wound edges with a soft debridement pad or ring curette to achieve pinpoint bleeding
- Identify local and spreading infection
- Select and apply an appropriate dressing
- Refer the patient to an expert practitioner

Expert practitioner/advanced training in wound care
(e.g., certified wound specialist, surgical advanced practitioner, surgeon or other specialist consultant)

- Diagnose and manage the underlying pathophysiology
- Use pharmacotherapy, as required
- Select and perform an appropriate method of debridement (e.g., surgical sharp debridement)
- Refashion the wound edges
- Suture, as required
- Select and apply an appropriate dressing

*Providers should follow their competencies and capabilities as determined by their local protocols, regulatory body, legal liability and local governing bodies.[1,2]

The holistic framework has three key elements: assess, manage and monitor. The four steps of the Wound Hygiene protocol are aspects of 'manage' focused on local wound management (*Figure 9*). This evolution of Wound Hygiene aims to encourage proactive healing (rather than reactive management) of wounds across the broader wound-healing trajectory. This more patient-centric holistic framework also seeks to shift the focus of wound care away from the wound in isolation and towards the wound in the context of other factors, including comorbidities, nutrition, mental health and socio-economic challenges.

Consensus statement: The three elements of the Wound Hygiene holistic framework (assess, manage and monitor) should be adapted to the relevant preoperative, intraoperative and postoperative phases of perioperative care – termed Wound Hygiene Surgical.

Clinical competency

Wound Hygiene Surgical can be performed by any health professional, regardless of skill and experience (*Box 3*).[1,2] Where a healthcare provider reaches the limits of their remit, they are advised to escalate to the next level. Even where a higher skill level is not available, the tasks carried out by those with little or no wound training or certification are key to proactive management of hard-to-heal wounds.

Consensus statement: Wound Hygiene Surgical can and should be implemented by health professionals involved in perioperative care at all levels of clinical competency, with adjustments by level.

Consensus statement: Wound Hygiene Surgical

Since it was introduced, Wound Hygiene has become increasingly well-established, and its practical applications have expanded in scope.[50] This development has been underpinned by key shifts in the understanding of biofilm and hard-to-heal wounds. As it has evolved, Wound Hygiene has become more closely aligned with the TIMERS (tissue, inflammation, moisture, edge, regeneration/repair and social factors) framework.[51]

Because Wound Hygiene was developed for use in any setting, it is suitable for adaption to the surgical arena. Therefore, the evolving practice of Wound Hygiene should be extended to create Wound Hygiene Surgical, a proactive healing strategy with a wound-management protocol within a holistic framework for perioperative care, focused on tackling biofilm to prevent or resolve surgical wound complications.

Section 3. Wound Hygiene Surgical: management protocol

This section presents the consensus panel's recommendations for how the four steps of the Wound Hygiene protocol of care should be implemented in surgical wounds. The Wound Hygiene Surgical protocol should be implemented from completion of the surgical procedure until the wound has fully healed. The management protocol for a surgical incision will depend on whether the wound is healing by primary, secondary or tertiary intention, including which steps of Wound Hygiene should be undertaken (*Figure 10*).

Primary intention

In wound healing by primary intention, the dermal edges of a surgical incision are brought together (approximated) and remain closed throughout the healing process (*Figure 11*). Approximation minimises tissue loss and aids healing. Surgical incisions through skin and underlying tissues can be approximated with a variety of materials, including sutures, staples/clips, tapes, skin adhesives or skin-closure devices.[52]

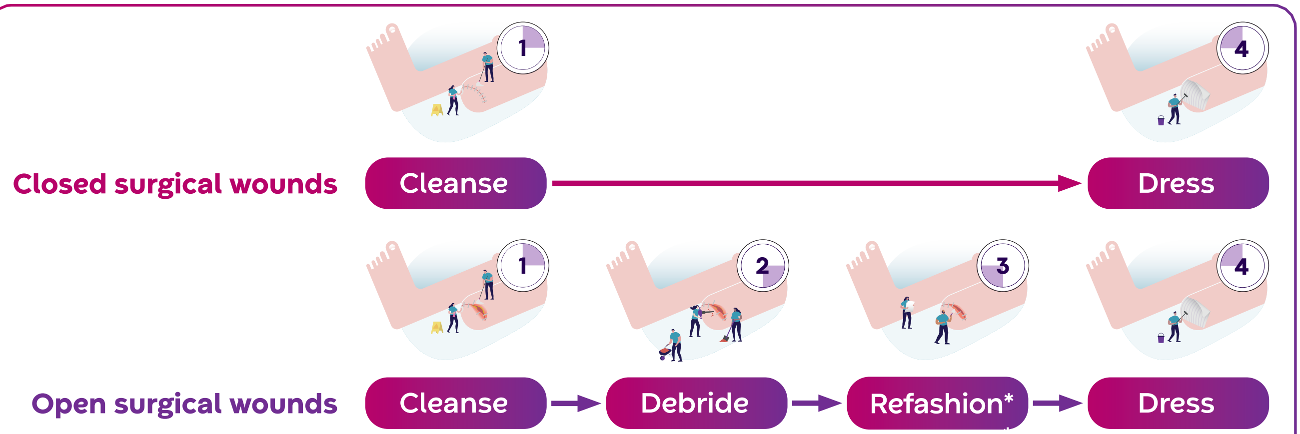
In healing by primary intention, application of the Wound Hygiene protocol should focus on prevention, helping to ensure the surgical wound does not progress to hard-to-heal status. The goal of this preventative strategy is to prevent any planktonic bacteria in the closed incision from seeding and resulting in biofilm formation. This involves implementation of steps 1 and 4 of Wound Hygiene: cleansing the wound and periwound skin (*Table 2*) and then dressing the wound (*Box 4*). However, in the absence of other assessed factors, there is no need to further disrupt the tissue through debridement and refashioning at the initial dressing change.[1,2,53] As a minimum requirement, closed incisions should be covered postoperatively with an appropriate interactive cover or water-resistant dressing. In closed incisions at high risk of acute infection, advanced antimicrobial dressings and negative pressure wound therapy (NPWT) can be considered, depending on clinical judgement, local protocols and availability.

Closed incisions that develop clinical signs of an SSI or harmful biofilm colonisation should be treated as actively (rather than potentially) hard-to-heal. As soon as possible after the signs are observed, the approximated wound edges should be opened by a practitioner with the appropriate clinical competence and in an appropriate clinical setting, after which a separate assessment must be made by the primary provider, and Wound Hygiene Surgical should be applied as appropriate for a wound healing by secondary intention.

Secondary intention

In wound healing by secondary intention, the dermal edges are not fully approximated, leaving the wound open. This includes incisions that have been left open deliberately, such as in an amputation site. These deliberate open wounds normally heal from the base

Figure 10. Protocol for local management of open and closed surgical wounds



*Wounds healing by tertiary may require refashioning of not only the wound edges but the entire wound bed, including healthy tissue

Table 2. Cleansing surgical wounds[1]

In all surgical incisions, the entire wound and periwound skin should be cleansed at each dressing change to reduce bacterial contamination that could lead to biofilm development. The cleansing solution should be non-cytotoxic (low-index cytotoxicity)[1,2] and selected according to local guidelines and protocols.

Type	Solution	Use
Non-antimicrobial	Pre-boiled potable tap water	Recommended only where other solutions are not available
	Sterile water	For single use only where other solutions not available
	Sterile normal saline	For single use only where other solutions not available
	Non-ionic surfactant	Recommended among the non-antimicrobial options
Antimicrobial	Polyhexamethylene biguanide (PHMB)	Can be used to penetrate hard-to-remove coatings, such as slough
	Octenidine dihydrochloride	Can be used to loosen dressings as well as carry out cleansing
	Hypochlorous acid	Can be used to loosen dressings as well as carry out cleansing
	Chlorhexidine gluconate	Can be used in diluted concentrations for cleansing, but caution should be taken because of the risk of contact dermatitis[67]

up via the natural pathways of granulation, contraction and epithelialisation.

Closed surgical wounds can also become open because of a complication (and thus hard-to-heal). Closed wounds that show signs of developing an SSI are deliberately reopened to allow access to infected tissue. Other closed wounds may undergo dehiscence, a complication where the wound edges separate at one or more points, with or without exposure or protrusion of underlying tissue, organs or implants. Dehiscence may or may not involve diagnosed infection, and not all infected or inflamed wounds progress to dehiscence.[4]

Open wounds, whether left intentionally open or resulting from SSI or dehiscence (*Figure 11*), should be managed with all four steps of the Wound Hygiene protocol of care.[1] Incisions showing signs of contamination and acute infection (e.g., exudate, slough, increased drainage or extension of wound size) must be cleansed within 48 hours, as specified in *Table 2*. Debridement should be followed by a second round of cleansing to remove any surviving bacteria. The edges of an open surgical wound should be refashioned, according to a method determined by wound assessment and practitioner skill level, to remove areas that can harbour biofilm and ensure that the skin edges are contiguous with the wound bed, to facilitate epithelial advancement and wound contraction. Open wounds should then be dressed as per *Box 4*. Open incisions showing signs of acute infection

Figure 11. Open surgical wounds

Wound left intentionally open

Wound open as a result of dehiscence

Box 4. Dressing surgical wounds

Dressing selection

Surgical wounds should be dressed to effectively manage residual bacteria, avoid formation or regrowth of biofilm and promote wound healing. The choice of specific dressing will be based on the wound's appearance, duration of care and healing response. This choice should be guided by clinical judgement, local protocols and availability, as well as comprehensive preoperative and postoperative assessments.

- As a minimum requirement, closed wounds must be covered postoperatively with an appropriate interactive cover or water-resistant dressing.
- All postoperative wound dressings should be sealed to prevent environmental and external contamination, and gauze alone is unsuitable for use as a primary external dressing in hard-to-heal wounds
- Surgical wounds with or at risk of acute infection can be treated with advanced antimicrobial or antibiofilm dressings with an agent that kills or inhibits growth of microorganisms; these address residual biofilm while preventing or delaying biofilm regrowth between dressing changes.
- The efficacy of a dressing should be assessed every 2–4 weeks.

Compression therapy

Surgical wounds can be managed with compression devices, such as bandages or adjustable wraps. Compression reduces oedema, improves venous return and tissue oxygenation, and may also prevent dressings from moving. Compression must be applied by a health professional with the requisite skills/training.

Negative pressure wound therapy

Use of negative pressure wound therapy (NPWT) may be considered in patients at a high risk of developing surgical wound complications.

- NPWT should be used with great caution in wounds with signs of local infection and generally avoided in wounds with spreading infection
- In surgical wounds, NPWT may be used for extended periods, in accordance with the manufacturer's instructions, dependent on local approval and in line with education provision to clinical and non-clinical end users.

Dressing application and removal

Dressings should be applied using a non-touch aseptic technique and saline solution. Initial postoperative dressings should be left in place for between 2 and 5 days. However, advanced dressings may be left in situ for up to 7 days, in accordance with the manufacturer's instructions, unless clinically indicated otherwise. When applying and removing adhesive dressings (including tapes and drapes), care should be taken to avoid the risk of trauma and medical adhesive-related skin injury (MARSI):

- Skin protection should be provided where indicated based on the patient's risk status
- Adhesive dressings should be applied without tension
- Adhesive removers can be used to protect the skin from the risk of MARSI during dressing removal, so long as the adhesive remover does not come into contact with the incision line or an open wound.

should be dressed with an advanced antimicrobial dressing or NPWT. In the event of an SSI, management may also require a pharmaceutical intervention, such as systemic antibiotics.

Tertiary intention

Surgical incisions healing by tertiary intention (also known as delayed primary closure) are initially left open before being surgically approximated at a later date. Before closure, these deliberately open wounds should undergo all four steps of the Wound Hygiene protocol to achieve wound bed preparation. First, the wound and periwound skin are cleansed with a non-cytotoxic solution. Then, surgical debridement is performed to remove any non-viable tissue likely to harbour biofilm. This is then followed by refashioning of not only the wound edges but also the entire wound bed, including healthy tissue. This surgical preparation of the wound bed is essential to optimise the chances of successful take of skin grafts, flaps or acellular, cellular and matrix-like products (CAMPs) by avoiding the risk of dead space and achieving low tension at the skin margin. Open wounds healing by tertiary intention may then be covered with an appropriate wound dressings. Once a wound healing by tertiary intention is ready to be closed, this is achieved with a technique that avoids tension, such as a skin flap, skin graft or CAMP. These reconstructive approaches provide a scaffold – taken from either human-based or human-like tissue – to promote tissue growth across the open wound.[54,55]

Reconstructive approaches in healing by tertiary intention can be supported with NPWT to help move the wound towards timely closure, depending on indication, patient risk status and manufacturer instructions.

Section 4. Wound Hygiene Surgical: holistic framework

This section presents the consensus panel's recommendations for how the Wound Hygiene holistic framework can be implemented as part of a proactive healing strategy in the surgical setting. The Wound Hygiene Surgical holistic framework should apply throughout the entire perioperative period, encompassing all multidisciplinary care provided to a patient from the moment of contemplation of surgery until full recovery.[56]

Wound Hygiene Surgical should be incorporated into existing published guidance and risk assessment models. Health professionals implementing Wound Hygiene Surgical should refer to any clinically appropriate national and international guidelines on best practice in the delivery of perioperative wound care (*Table 3*). The antibiofilm focus of Wound Hygiene Surgical is a valuable supplement to guidelines that do not acknowledge the presence of biofilm.

Assessment and monitoring of the patient, their wound and its context are key to successful implementation of Wound Hygiene Surgical throughout the preoperative, intraoperative and postoperative periods. Full holistic assessments are essential for identifying any underlying risk factors for surgical wound complications, while ongoing monitoring allows for early identification and treatment of developing infections.[12,27,28] Assessment and monitoring should follow local guidance and can be aided with a variety of established risk-assessment tools for surgical complications, including SSIs (*Box 5*). These models include manual and automated risk calculators, and some may be more or less applicable to

Table 3. Guidance on perioperative wound care and surgical site infections

Guideline	Source
ERAS guidelines	ERAS Society (2024)[68]
Best practice statement: promoting a seamless patient journey from surgery to community	Wounds International (2023)[69]
Recommendations for modern perioperative care for elective surgery: consensus of panel of experts (also in Polish)	Klek et al (2023)[70]
Surgical site infection: prevention and management across health sectors	EWMA (2020)[71]
Perioperative care in adults	NICE (2020)[72]
Postoperative wound care: reducing the risk of surgical site infection	Younis et al (2020)[73]
Surgical site infections: prevention and treatment	NICE (2019)[74]
Consensus on wound antisepsis: update	Kramer et al (2018)[75]
Surgical wound dehiscence: improving prevention and outcomes	WUWHS (2018)[4]
Best practice recommendations for the prevention and management of surgical wound complications	Wounds Canada (2017)[76]
Guidelines for the prevention of surgical site infection	CDC (2017)[77]
Closed surgical incision management: understanding the role of NPWT	WUWHS (2016)[78]
Nosocomial infection surveillance programme at Catalan Hospitals (VINCat)	Catalonia Health Ministry (2015)[79]

Note: None of these guidelines should be recommended in favour of another, and they are presented here without prejudice.

CDC=Centers for Disease Control and Prevention; ERAS=Enhanced Recovery After Surgery; EWMA=European Wound Management Association; NICE=National Institute for Health and Care Excellence; WUWHS=World Union of Wound Healing Societies certain regions and facilities than others. Assessment and monitoring should also be supported with the Wound Hygiene Surgical checklists for preoperative, intraoperative and postoperative risk factors (*Checklists 1–4*).

Preoperative period

Assess: preoperative assessment

Assessment should start before surgery with an initial comprehensive whole-person assessment of the various intrinsic patient factors that might increase their risk of developing an SSI, as well as other surgical risk factors that can be identified before the operation (*Checklist 1*).[6,21,23–29,57] The likelihood of an SSI arising depends on the type, circumstances and anatomical location of the surgery. An optimal preoperative assessment will allow health professionals to stratify the patient's risk level, as well as to create plans to address these factors to the extent possible before surgery.

Manage: prehabilitation

Preoperative assessment should be followed by prehabilitation to manage, mitigate or prepare for any identified risk factors as much as possible before surgery.[21,58,59] The creation and implementation of a prehabilitation plan should be a collaboration between the health professional and patient.

Prehabilitation is typically multifactorial, and it may involve supporting a patient with their nutrition status, glucose control and management of any comorbidities or existing infections, as well as help with decreasing behaviours such as smoking and alcohol use, with the goal of strengthening the immune system against the planktonic bacteria anticipated to be present after surgery.[21,58,59] Prehabilitation has been shown to decrease the rate of postoperative complications, length of hospital stay and treatment costs, as well as improve the perioperative transfusion rate, antibiotic administration and patient adherence to postoperative recommendations, such as physical activity.[1]

Intraoperative period

Assess: intraoperative assessment

On the day of the operative procedure, the patient's physiological and psychological status should be assessed and recorded. This should add to and update the information gained from the preoperative assessment and help guide intraoperative and postoperative care, promoting patient safety and privacy at all times.

Manage: antisepsis

Antisepsis should be maintained throughout intraoperative period, in adherence to local and institutional guidance. Antisepsis is essential to reduce the risk of infection and related complications, as well as a vital part of Wound Hygiene Surgical's antibiofilm approach to wound healing. Antiseptic technique includes hand hygiene, antiseptic skin preparation skin and maintenance of a sterile field.[21,59,60] The risk of local and systemic infection may also be reduced with the following preoperative activities:[21,58,59,61]

- Advising patients to shower with soap and water the night before and day of surgery
- Considering a skin decolonisation regimen for the patient
- Considering nasal decolonisation
- Administering antimicrobial prophylaxis, only when indicated and based on local or organisational guidelines
- Maintaining glucose control and normothermia throughout the surgery day, starting preoperatively
- Cleansing any skin folds
- Avoiding hair removal where possible
- If hair removal is required, using clippers instead of shaving
- Preparing the incision site with an alcohol-based antiseptic solution.

Box 5. Surgical risk assessment tools

- Carolinas Equation for Determining Associated Risks (CeDAR)[80]
- Clinical predictors of major infections after cardiac surgery[81]
- Early identification and prevention of surgical wound complications (ISCWAP, 2020)[82]
- European System for Cardiac Operative Risk Evaluation (EuroSCORE) II[83]
- Infection Risk Index in Cardiac Surgery[84]
- Optimizing prevention of surgical wound complications: detection, diagnosis, surveillance and prediction (ISCWAP, 2022)[85]
- Perth Surgical Wound Dehiscence Risk Assessment Tool (PSWDRAT)[86]
- Portsmouth Physiologic and Operative Severity Score for the Study of Mortality and Morbidity (P-POSSUM)[87]
- Risk factors and prediction model for inpatient surgical site infection after major abdominal surgery[88]
- Surgical site infection risk prediction models in colorectal surgery[89]
- Surgical Site Infection Risk Score (SSIRS)[90]
- National Nosocomial Infections Surveillance System (NNISS)[91]

ISCWAP=International Surgical Wound Complications Advisory Panel

Health professionals involved in the surgical care of high-risk, speciality-specific patients should refer to local institutional guidelines for how to treat existing contamination or infection (e.g., yeast in skin folds).

Manage: surgical technique

During an operation, surgeons and other operating-theatre personnel should aim to minimise blood loss and pooling of liquid/oedema to avoid creation of a cavity or 'dead space'.[6,12,21,26,27,47,57,62] The practice of surgical irrigation is not standardised, and there is limited evidence on irrigation and the choice of cleansing solution and/or topical antibiotics in the operating theatre pre-wound closure. Decisions on intraoperative irrigation, cleansing and antibiotics should be based on local guidance and a risk assessment of the patient and the operative procedure.

Guidelines note the importance of good surgical technique for closure of incisions.[58] After closure, the surgical wound should be irrigated with a cleansing solution. Cleansing is typically performed with saline. However, the evidence on irrigation is limited, and practice can vary according to type of surgery and patient risk level. Surgeons should make clinical decisions on irrigation after closure according to type of surgery and patient risk level.

Monitor: intraoperative monitoring

During surgery, it is important to monitor for any intraoperative factors that might increase the risk of surgical wound complications (*Checklist 2*).[6,12,21,26–28,57] Noting down these factors can guide healthcare professionals to implement proactive plans to reduce the risk of such postoperative complications. A key intraoperative risk factor for surgical wound complications is whether the operation is classified as clean, clean-contaminated, contaminated or dirty, as delineated by the CDC and European Wound Management Association (*Figure 12*).[21] All members of the surgical team (including surgeons and nurses) are responsible for recording events that occur during an operation and, once completed, classifying the procedure accordingly.

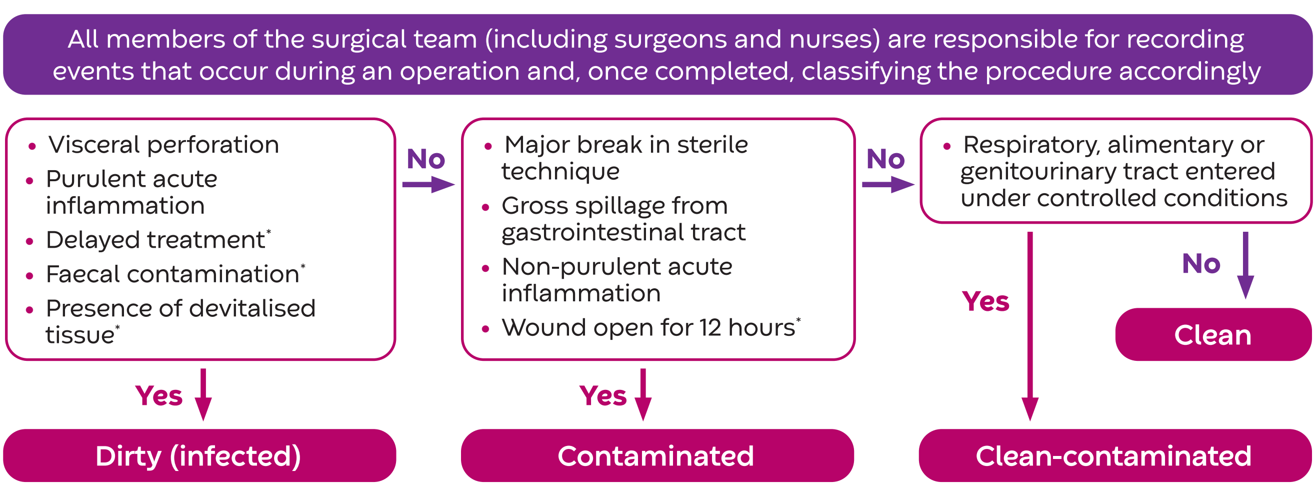
Postoperative period

Assess: postoperative assessment

After the operation, there should be an assessment of the surgical wound, as well as any changes to the patient's physiological and psychological status. Thorough and accurate assessment is critical to ensure that the correct management approaches are undertaken, including implementation of the Wound Hygiene Surgical management protocol, as well as to set healing objectives to be achieved as part of a proactive healing strategy. This assessment should include postoperative risk factors for SSIs (*Checklist 3*),[63,64] as well as the following local wound-related factors:[2]

- Condition of the periwound skin
- Condition of the wound edges (flat or raised)
- Exudate level (low, medium or high)
- Exudate type (serous, sanguineous, serosanguineous or purulent)
- Proportion of different tissue types on the wound bed
- Wound size
- Wound-related pain levels.

Figure 12. Classification of surgical procedures by contamination risk



Note: *Traumatic wounds

Checklist 1. Preoperative risk factors for surgical site infection

Behavioural and psychosocial patient risk factors

- ☐ Psychological stressors, e.g., isolation; unhealthy family relationships; fear, depression and anxiety; stress; pain; lack of sleep and poor sleep quality/sleep style (e.g., sitting)
- ☐ Smoking
- ☐ Inappropriate alcohol consumption
- ☐ History of intravenous drug use
- ☐ Imbalanced diet, malnutrition or poor glucose control
- ☐ Poor hydration status

Health-related patient risk factors

- ☐ Body type (obese or underweight status)
- ☐ Diabetes mellitus
- ☐ Cardiovascular disease (e.g., peripheral arterial disease, coronary artery disease, chronic venous disease or lymphoedema)
- ☐ Immunosuppression (e.g., because of medication or radiation therapy)
- ☐ Cancer
- ☐ Laboratory values (e.g., haemoglobin level; hepatic, renal, thyroid function)
- ☐ Immobility or lack of dexterity leading to repetitive stress or overload of the skin surface
- ☐ Neuropathy
- ☐ Underlying systemic infection or osteomyelitis
- ☐ Coexistent infection at a remote site
- ☐ American Society of Anesthesiologists score ≥2

Non-modifiable patient risk factors

- ☐ Advanced age (≥65 years)
- ☐ (Auto)immune disorders (e.g., rheumatoid arthritis or systemic lupus erythematosus)
- ☐ Genetic conditions (e.g., chromosomal disorders)
- ☐ Surgical risk factors
- ☐ Emergency/traumatic surgery
- ☐ Contaminated/dirty surgery of the bowel, rectum or vagina
- ☐ Long surgery duration (i.e., more than 2 hours)
- ☐ Complex surgery (i.e, open surgery of the abdomen, cardio-thoracic region or spine vs minimally invasive procedures)
- ☐ Use of foreign material (e.g., prosthetics)

Checklist 2. Intraoperative risk factors for surgical wound complications

- ☐ Surgery that traumatised or impacted the viability of tissue (e.g., as a result of poor surgical or suture technique that occurred during the procedure)
- ☐ Hypothermia
- ☐ Extended perioperative scrub time
- ☐ Oedema/pooling of bodily fluids
- ☐ Bleeding/need for blood transfusion
- ☐ Local ischaemia
- ☐ Creation of a cavity/space (e.g., through implantation of foreign material, such as use of drains)

Checklist 3. Postoperative risk factors for surgical site infection

- ☐ Poor aseptic technique for local surgical wound management
- ☐ Increased length of hospital stay
- ☐ Poor overall postoperative patient hygiene
- ☐ Poor postoperative glycaemic control
- ☐ Prolonged surgical drain placement
- ☐ Surgical dressings removed within 24 hours

Checklist 4. Postoperative signs of surgical site infection

Classical signs

- ☐ Heat (calor)
- ☐ Pain (dolor)
- ☐ Redness (rubor)
- ☐ Swelling (tumor)
- ☐ Low-grade fever
- ☐ Loss of some degree of function

Further signs and symptoms

- ☐ Increased exudate/drainage
- ☐ Slough
- ☐ Extension of wound size
- ☐ Wound not moving towards healing by postoperative day 3

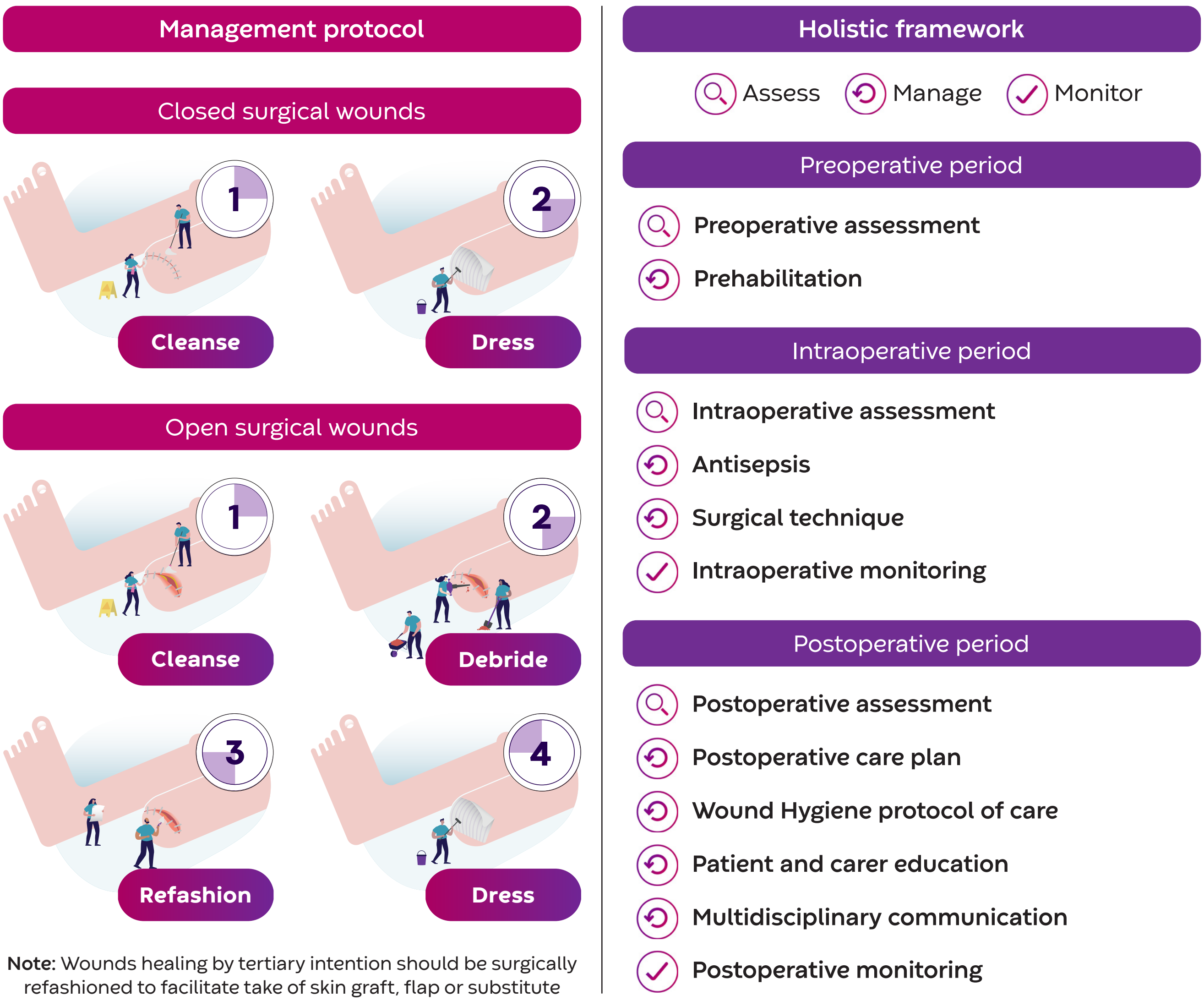
Manage: postoperative care plan

To ensure continuity of care after discharge, patients should be provided with a clear care plan. This plan should be individualised to the patient and informed by preoperative assessments and the prehabilitation process. The plan should aim to mitigate risk factors for postoperative wound complications with appropriate implementation of the Wound Hygiene Surgical protocol of care (*Figure 13*). This can be supported by an antibiotic medicine regimen in settings where there is a high risk of infection. It may also involve managing factors such as comorbidities, nutrition and glucose status. Analgesia should be considered to help reduce the pathological effects of pain, in which pain causes hormonal dysregulation, resulting in an immunosuppressive effect that can impair wound healing.[65]

Manage: patient and carer education

At discharge after surgery, patients and their families or carers should be given accessible guidance on postoperative wound care, with the information varying depending on the wound type. This may cover the dress step of the Wound Hygiene protocol, including the frequency of dressing changes and who will be performing them, with instructions on how to change the dressings and reminders not to touch the wound. Patient information should explain what can be done to support healing and minimise the risk of postoperative wound complications, and it should stress the importance of nutrition, glycaemic control and avoidance of smoking and alcohol for good healing outcomes, as well as continuing management of comorbidities. Patients should be made aware of the clinical signs and symptoms

Figure 13. Wound Hygiene Surgical: a proactive healing strategy for surgical wounds



of colonisation and infection, including heat, pain, redness or swelling at the surgical site and elevated body temperature or exudate.[21] They should also be informed of who to contact and how to get in touch if they have any questions or concerns, including if they observe signs of infection. Education can be provided in different formats or media types for greater reach and broader accessibility.

Manage: multidisciplinary communication

Implementation of Wound Hygiene Surgical requires appropriate channels of communication to be established across the care team and between health professionals, patients and carers. Effective standardised communication across the care team is vital for ensuring standardisation of care and thus supporting good wound-healing outcomes. The postoperative care plan should be communicated to all health professionals and community staff involved in the patient's postoperative wound care, along with robust documentation and instructions for communication expectations. Members of the care team should also receive education on biofilm to raise their awareness of its implications and how it can be managed, including guidance on performing the four steps of the Wound Hygiene. This can help address the disparity in biofilm recognition between surgical and wound care teams caused by a lack of overlap between healthcare professionals working in the two disciplines.

Monitor: postoperative monitoring

Postoperative surgical wounds need to be monitored on an ongoing basis for signs of bacterial colonisation, biofilm formation and local or spreading infection. Postoperative monitoring will inform whether the management steps of Wound Hygiene Surgical protocol should be stepped up or down. As SSIs often present post-discharge in patients with closed incisions,[66] monitoring must be performed for at least 30 days, with the duration depending on the type of surgery. For example, the presence of a prosthesis will necessitate at least 90 days of monitoring.[6] Routine visual assessments should be arranged in a timely fashion and scheduled in the postoperative care plan. Monitoring should include a full assessment at every dressing change for signs and can be timed to coincide with guidance for how long the chosen dressing type needs to stay in place after each application. Telemedicine can be considered if it is appropriate, available and acceptable to the patient.

Postoperative factors to look for include the classic signs of clinical infection – heat, pain, redness and swelling, typically manifesting in a low-grade manner – as well as symptoms that can arise because of biofilm colonisation in the absence of the classic signs (*Checklist 4*).[1,60] For the first few days after surgery, these signs of inflammation at the incisional site are normal and do not necessarily indicate infection. However, signs of inflammation that exceed the duration or extent expected for normal healing instead indicate that the wound may be becoming hard-to-heal and at risk of SSI and dehiscence.

Visual monitoring of the surgical wound should be performed in line with the local protocols. Wound Hygiene Surgical checklists (*Checklists 1–4*) should form part of the standard documentation of these assessments, such as electronic patient records. These checklists will fulfil local mandatory field SSI surveillance programmes, as well as help monitor the effect of interventions on patient outcomes. Patient-reported outcomes should be included in any appraisal of the effectiveness of Wound Hygiene Surgical to capture the patient experience. In addition, these checklists will ensure that healthcare professionals with responsibility for wound care have been conducting the prescribed steps of Wound Hygiene as required and in the right sequence.

In the event of complications, assessment materials for community health professionals should specify when to refer on and who to refer to. If local signs of inflammation, infection or ischaemia are observed, the wound dressing should be removed for inspection and the underlying cause(s) addressed. If systemic signs of infection are observed, the wound should be inspected using sterile touch technique; this evaluation must be made in the operating theatre.

Conclusion

As disciplines, wound care and surgery are rarely well connected. Consequently, specialists in these fields tend to work in silos and are unlikely to share practice information with their counterparts in the other specialism, nor communicate across the full continuum of patient care. For example, surgical specialists may not get to see surgical wounds that develop SSIs or dehiscence and thus may remain unaware of their impact on patients and how they can be managed. Similarly, wound specialists might be unfamiliar with how to care for surgical wounds, as the vast majority of hard-to-heal wounds they work with are diabetic foot ulcers, pressure ulcers/injuries and leg ulcers of all aetiologies. This lack of integration between disciplines is likely to be a factor that allows surgical wounds to fall victim to impaired healing processes, develop complications and become hard to heal.

Advancing Wound Hygiene from being the sole purview of wound specialists and into the perioperative realm will help break down the systemic communication barriers between these disciplines. This will allow for greater cross-pollination between wound care and surgery, as well as achieve the shared objective of improving patient outcomes.

The Wound Hygiene Surgical protocol seeks to eradicate biofilm as the main factor in surgical wounds developing complications and becoming hard to heal. This should be a proactive healing strategy supported by a holistic framework at every stage of the perioperative journey (*Figure 13*). The prevention-first strategy of Wound Hygiene Surgical aims to lower the incidence of SSI and dehiscence, while its proactive approach to management is intended to overcome these complications and prevent infected surgical wounds from becoming more severe.

It is the panel's ambition that the two disciplines of wound care and surgical care will share in endorsing the integration of a proactive antibiofilm approach to surgical wound care, and a new audience will recognise biofilm as the fundamental underlying principle of moving a wound towards healing.

Appendix 1. Glossary of key terms

Approximation Bringing together the edges of a wound, as with sutures, glue or staples

Antibiofilm approach Care strategy aimed at removing biofilm and preventing its formation and regrowth

Biofilm Complex community of bacteria and fungi that causes a sustained subclinical infection, resists host immune response and antimicrobial intervention and is present in all wounds

Cleansing Use of a non-cytotoxic solution to remove devitalised tissue, debris and biofilm from the wound bed, and dead skin scales and callus from the periwound skin

Closed surgical wound Surgical incision where edges have approximated

Closure See approximation

Chronic wound See hard-to-heal wound

Complex wound Wound presenting with factors that put it at risk of becoming hard to heal

Compression therapy Use of bandages or other products that apply pressure to manage extremity wounds with underlying venous disease

Debridement Removal of non-viable tissue from a wound bed

Dehiscence Separation of wound margins at one or more points of a closed surgical wound

Delayed primary closure See tertiary intention

Epithelial tissue Viable tissue in a wound bed that is typically pink or white and results from growth of new skin cells, closing the wound and restoring barrier function

Hard-to-heal wound Wound that has failed to respond as expected to standard of care

Healing ridge Thickened tissue that forms as part of healing progress, indicating newly formed collagen, and that can be felt along either side of a surgical incision or wound

Healthy granulation tissue Viable tissue in a wound bed that is typically moist, shiny, cobblestone-like and bright red and results from growth of blood vessels and connective tissue before epithelialisation

Medical-adhesive related skin injury Injury to periwound skin caused by traumatic application and removal of adhesive devices

Necrotic tissue Non-viable tissue that is typically dry, hard or leathery; black, brown or grey in colour; and a result of ischaemia or sometimes infection

Negative pressure wound therapy Application of subatmospheric pressure to remove excess exudate from a wound

Open surgical wound Surgical wound where the edges are not fully closed (approximated), whether intentionally or as a result of dehiscence or other complication

Perioperative care All the holistic, multidisciplinary care given to a patient undergoing surgery from the moment of contemplation of surgery until full recovery

Prehabilitation Structured mitigation of preoperative risk factors for surgical complications

Primary intention Healing process for a closed wound

Refashioning Removal of necrotic, crusty or overhanging wound edges so they align with the wound bed or refashioning healthy tissue as an integral part of wound bed preparation for healing by tertiary intention

Secondary intention Healing process for an open wound

Sloughy tissue Non-viable tissue that is typically moist, soft, stringy or mucinous; yellow, white or green in colour; and caused by cell death during the inflammatory process

Surgical site infection Infection at a surgical site occurring within 30 days of surgery (90 days with an implant), including only skin, subcutaneous tissues, deep tissue layers or direct organs, and exhibiting purulent drainage or microbial organisms isolated from the wound site (or any surgical wound re-opened for cleaning)

Surgical wound complication Unintended event arising at the site of an intentional surgical wound

Tertiary intention Healing process where a wound is initially left open and then approximated at a later date

Unhealthy granulation tissue Tissue in a wound bed with a flat surface and pale pink colour that may be non-responsive, prone to bleeding and/or malodourous and results from failure to progress because of a destructive inflammatory response to biofilm

Wound Hygiene Antibiofilm protocol of care for hard-to-heal wounds with four steps (cleanse, debride, refashion, dress) and a three-phase holistic framework (assess, manage, monitor)[1,2,51,89]

Appendix 2. Selected literature demonstrating the trajectory of research on wound biofilm

Authors	Subject	Approach	Outcome
Gjødsbøl et al (2006)[93]	Bacterial profile of hard-to-heal VLUs (relevant to, but not specifically on, biofilm)	Wound samples from 46 patients collected every 2 weeks for 8 weeks processed via culture analysis	More than one bacterial species was present in all 46 wounds, with multiple bacterial species found in 76% of the wounds. *Staphylococcus aureus* and *Pseudomonas aeruginosa* were the most commonly present, with the presence of *P. aeruginosa* correlated to larger wound size
Bjarnsholt et al (2008)[94]	Why VLUs, PUs and DFUs become hard to heal	Fluorescence analysis of sections from non-healing wounds in situ hybridisation	Distinct microcolonies were found, and the basal structures of bacterial biofilms identified, leading the researchers in this paper to hypothesise that the presence of *P. aeruginosa* in biofilms leads to resistance to eradication
Davis et al (2008)[95]	Validity of criteria for defining biofilm-associated disease in wounds	*S. aureus* inserted into porcine partial-thickness wounds then treated 15 minutes or 48 hours later with topical antimicrobial; effectiveness assessed with in vivo antimicrobial assays (light, scanning-electron and epifluorescence microscopy of microbial communities)	Biofilm-like structures developed after just 48 hours, with *S. aureus* embedded in the microbial colonies that had grown. Both topical antimicrobials exhibited efficacy against planktonic *S. aureus* but low efficacy against biofilm-embedded *S. aureus*. Microbial colonies encased in an extracellular matrix in the wound were tolerant to the topical antimicrobials.
James et al (2008)[96]	Characteristics of biofilm in hard-to-heal and acute wounds	Light and scanning-electron microscopy; molecular denaturing gradient gel electrophoresis; and sequence analysis	30 of 50 hard-to-heal wounds and 1 of 16 acute wounds contained biofilm. Molecular analysis showed polymicrobial makeup of the wound colonisation, including anaerobic bacteria, which were not seen in the culture results. Bacterial biofilm was polymicrobial and prevalent in hard-to-heal wounds
Kirketerp-Møller et al (2008)[97]	Nature and role of bacterial colonisation in wound healing	Standard culture and PNA FISH in 22 wound samples with suspected *P. aeruginosa*	Culture showed *S. aureus* dominance, with less frequent presence of *P. aeruginosa*; PNA FISH demonstrated *P. aeruginosa* in a larger proportion of wounds, demonstrating the potential for inaccuracy when culturing wounds in practice. In addition, PNA FISH showed existence of microbial communities, with *P. aeruginosa* embedded in, aggregating in a self-produced matrix and exhibiting behaviours of biofilm.
Kennedy et al (2010)[98]	Presence of biofilm in burn wounds (first study on topic)	Light and electron microscopy on 11 burn wound biopsies; stains used to identify specific micro-organisms and biofilm components	This was the first study to find that biofilm is present in burns.

Authors	Subject	Approach	Outcome
Dalton et al (2011)[99]	Relationship between biofilm and hard-to-heal wounds	Single and multispecies (Gram-negative and Gram-positive, aerobic and anaerobic bacteria) biofilms grown in vitro and transplanted onto wounds in mice	The multispecies transplants resulted in multispecies biofilms that were resistant to antimicrobials and displayed impaired wound healing compared with the single-species transplants
Elgharably et al (2013)[100]	Presence of biofilm in deep sternal wound infection (high-risk complication of cardiac surgery)	Gram staining, SEM and confocal laser scanning microscopy to analyse sternal wires in patients having repeat median sternotomy for elective cardiac surgery, with dehiscence or without infectious complications	The sternal wires of all six patients with sternal wound dehiscence were found to have staphylococcal colonisation; no colonisation was found in three non-infected control sternal wounds without infectious complications
Ashrafi et al (2018)[101]	Biofilm formation, bacterial VOC in vitro, validation of human incisional and excisional cutaneous wound models ex vivo	Multiple microscopy and metabolic and biomass assays to assess biofilm development; gas chromatography-mass spectrometry to assess VOC production measured by gas chromatography-mass spectrometry	First demonstration of bacterial biofilm formation in human ex vivo cutaneous wound models, along with the biofilm-specific VOC profiles
Kalan et al (2019)[102]	Role of biofilm in healing, interventions and outcomes in DFUs	Longitudinal, prospective study on cultured wound isolates subjected to metagenomic shotgun sequencing to unpick the biofilm makeup	Presence of S. *aureus* correlated to poorer healing outcomes. Microbes typically considered neutral increased wound severity and impeded healing. Genes for antibiotic resistance were identified and widespread. Debridement was more effective than antibiotics in shifting microbiota to move towards healing.

DFU=diabetic foot ulcer; PNA FISH=peptide nucleic acid-based fluorescence in situ hybridisation; PU=pressure ulcer
VLU=venous leg ulcer; VOC=volatile organic compound

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