Criteria for identifying wound infection

Relying on traditional indicators of wound infection may cause delay in detection. The authors of this paper provide additional criteria that help identify infection in granulating wounds

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Wound infection; Assessment

Historically, infection of a wound was almost predictable and today wound infection remains a persistent problem. About 140 years ago Semmelweis reported a 10% mortality rate owing to puerperal sepsis, and Simpson reported a mortality rate of 10–40% following amputation[1].

A review of patients' records for 1925 indicated to Meleney that the clean wound infection rate was 14%[2]. A US study in 1964 reported an overall incidence of postoperative wound infections of 7.4% in 15 613 operations[3] and a more recent national study in the UK showed that, following surgery or traumatic events, 5% of wounds will become infected[1].

Wound infections have been found to cause 290 additional bed days for one group of 40 surgical patients[4]. A study of staphylococcal wound infections in postoperative general surgical patients found that discharge from hospital was delayed by eight days[5]. In another study, the average hospital stay doubled when wound infection developed after any of six commonly performed operations[6]. Ultimately, the worst result of infection — death — still occurs[7].

The cost of postoperative wound infection resulting in bed occupancy in England and Wales for 1973 has been estimated at £20 million[8]. In addition to the patient's absence from work, payments for compensation and operating again have to be considered. The cost to the USA of surgical infection in 1969 was $9,8 billion[9].

The effects of a wound infection may exact a personal toll and can counteract the benefits to the patient that should have resulted from the surgery. The patient's self-esteem may suffer, his or her wage-earning capacity may be affected and he or she may be deprived of home and family through an increased hospital stay.

Identifying wound infection

Traditional approaches

Criteria used to identify infection may often be restricted to the presence of pus, or pus with inflammation[1]. Traditional criteria have been used in many surveys and their advantage is that they are simple, reproducable and easily recognised by different observers. It is not denied, however, that identification of infection may be difficult in some circumstances, and that identifying patients who are likely to develop infection is remote. Lawrence supports the view 'that the presence of pathogens in wounds not exhibiting visual evidence of infection cannot be ignored[10].'

Traditional definitions of wound infection may be too narrow to account for the variety of ways in which infection may manifest in granulating wounds. Not only may the use of inadequate criteria disadvantage the patient, but it may also lead to complacency among clinicians.

In reality, infection rates may be higher than those recorded. This point is reflected in one study when the reported prevalence of 15.6% in 3354 wounds dropped to only 6.9% when pus was considered to be the only criterion of infection[11]. Inadequate criteria may lead to patients being discharged with unrecognised infection in their wounds[12]. In a study comparing infection rates in two Canadian hospitals, it became evident that 21.6% of infections were diagnosed only after patients had been transferred home. In a UK study, 13% of wounds were treated for infection after patients had been discharged[13].

A new approach

In view of the above problem, the identification of wound infection may be assisted by the criteria presented in Table 1, together with reasons for their inclusion. These criteria may be applied to a variety of wounds healing by second intention (open or granulating wounds) that are formed as a result of surgery, but are not considered to be applicable to burns or leg ulcers, as they have not been tested in these situations.

Some of these criteria may be widely used already in an unstructured way in clinical practice. Traditional criteria, such as haemopurulent fluid and pus may be observed when infection is present in sutured wounds. The suggested additional criteria, applicable to granulating wounds, may not be so familiar. The order in which they appear is not intended to imply any form of ranking of importance.

Traditional criteria

Abscess

This consists of a local collection of necrotic tissue, bacteria and white cells known as pus[14]. This collection of infection is retained within a wall formed by phagocytes and strands of fibrin[15]. In some instances this membrane may not be able to contain the pus and the build-up of pressure within the membrane may induce bacterial spread along tissue planes or via the vascular or lymphatic systems.

Cellulitis

Here, bacterial infection (most likely caused by haemolytic streptococcus) causes a spreading, non-suppurative

inflammation of the skin and subcutaneous tissues. The diagnosis usually depends on the presence of erythema and local heat. Pain or tenderness may also be present and may be accompanied by local oedema. In severe infections, vesicles, pustules and even ulceration and necrosis may develop. The infection does not readily produce systemic complaints, but local pain can be disturbing to the individual. Lymphangitis and regional node involvement may be evident.

Discharge

A discharge may be expected from a freshly formed wound. This discharge of serum, leucocytes and wound debris usually has a specific gravity of 1020 or greater and it usually diminishes as the healing of the wound progresses. The amount of this exudate is difficult to quantify but should not be excessive. It is usually greater in quantity and slower to decrease in volume in deep, large wounds and is considered to have a bactericidal effect[16]. Nutrient properties are also thought to be present in wound exudate[17].

Cytokines, polypeptide growth factors that have been found to promote wound healing, have also been identified[18,19]. Bacterial enzymes (proteases) in wound fluid may have a detrimental effect on the skin as they assist in the liquefaction of tissues[20].

Inflammation is the local tissue response to wounding or bacterial invasion. Inflammation is also a cellular response that follows tissue injury of any type; it is a natural and vital part of the reparative process.

The function of this inflammatory stage of the healing process is to remove dead cells and micro-organisms and to stimulate healing. An acute inflammatory reaction can be expected up to approximately three days after surgery.

The following types of discharge may be indicative of wound infection:

- Serous exudate with concurrent inflammation. It has been stated that wounds that drain serous fluid and are inflamed should be classified as 'possibly infected' if micro-organisms are cultured. In one study, a serous discharge was suspected of indicating infection and swabbed for laboratory culture[21]. In another study of postoperative wound infection, wounds were deemed infected if there was clinical inflammation with serous discharge[22].
- Seropurulent and haemopurulent discharges. Suppuration is the result of liquefaction of tissues in the presence of micro-organisms and is possibly the most widely accepted indicator of wound infection.
- Pus may take on various shades of yellow, green or grey and the inexperienced observer may confuse it with normal wound exudate or even moist, devitalised tissue (slough). 'A definitely infected wound drains purulent material whether or not micro-organisms are identified by culture'[23].

Table 1. Criteria to assist in the identification of infection in granulating wounds

Traditional criteria

1. Abscess
2. Cellulitis
3. Discharge
   - (a) Serous exudate with inflammation
   - (b) Seropurulent
   - (c) Haemopurulent
   - (d) Pus

Suggested additional criteria

4. Delayed healing (compared with normal rate for site/condition)
5. Discoloration
6. Friable granulation tissue which bleeds easily
7. Unexpected pain/tenderness
8. Pocketing at base of wound

8(a). Bridging of the epithelium or soft tissue

9. Abnormal smell
10. Wound breakdown

Suggested additional criteria

Delayed healing

An experienced clinician can estimate the expected wound healing time. If delayed healing needs to be confirmed then, in certain wound types, a formula may be used.

A wound may be slow to heal for reasons other than infection: poor diet, use of steroids or non-steroidal anti-inflammatory drugs and diabetes can all have a detrimental effect on the healing rate of a wound.

Marks et al. studied three groups of patients with open granulating wounds and their healing rates[24,25]. The formulae they suggest to predict the healing time (where WD is wound dimension) are as follows:

- Laparotomy wounds:
  (WD x 1.19) + 3.6 days
- Pilonidal sinus excisions:
  (WD x 1.23) + 4.3 days
- Axillary skin excisions:
  (WD x 0.76) + 6.7 days.

Open granulating wounds need to be of a regular shape for the predicting formula to have any degree of accuracy. These calculations can be used only with wounds that heal mainly by contraction, as in those described above.

For wounds that heal mainly by epithelialisation, the observer should see advancement of the margin of epithelium of up to 5mm each week[26].

Discoloration

If the wound is discoloured (Fig 1) this may also be an indicator of infection. Before looking for discoloration it is helpful to be familiar with what may be considered as the normal colouring of a wound. Descriptions of healthy granulation tissue vary and are often brief. One author suggests a pink, moist, translucent appearance; another notes that healthy granulation tissue has a fine, granular surface and is red with a velvety texture[27].

When infection is present the surface of a wound may appear dull with patches of greenish discoloration[26]. Discoloration may manifest in other forms. Anaerobic infections, such as *Bacteroides fragilis* and anaerobic streptococci, promote the formation of dullish tissue, which may take on a dark red hue and give the wound what may be described as a 'sullen' appearance.

When considering specific bacteria, pseudomonal infections are renowned for demonstrating a green or blue appearance, which may fluoresce.

It has been observed that some wounds develop a yellowish coating, which, if removed, will recur a few days later. The presence of this membrane, which consists of fibrin and is not indicative of infection, is somewhat dependent on the dressing used and will not be seen if a hydrocolloid or alginate dressing is used.

Friable granulation tissue

When granulation tissue is friable and bleeds easily (Fig 2), either spontaneously or on light pressure, it is an indicator of infection[25]. This infected tissue, which is tender, has a gelatinous texture and gives the wound a raw, red appearance.

Unexpected pain in a wound

This may be of a throbbing nature and is caused by swelling and increased tension that results from the rise in tissue fluid (Fig 3). Other causal factors for the pain are the presence of toxins and hydrogen ions[28]. Infection may be detected by lightly

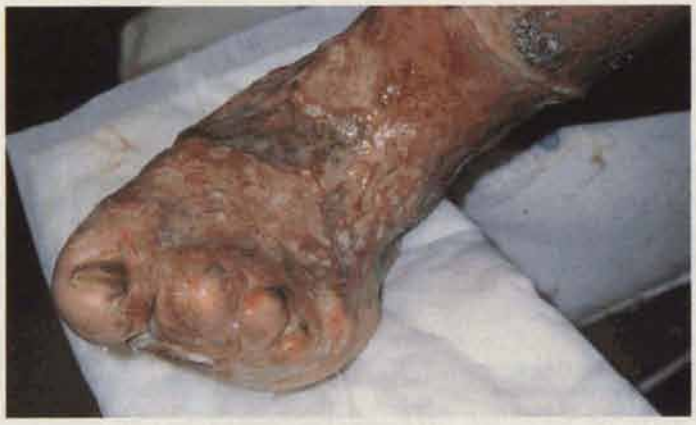

Fig 1. Discoloration may be indicative of infection

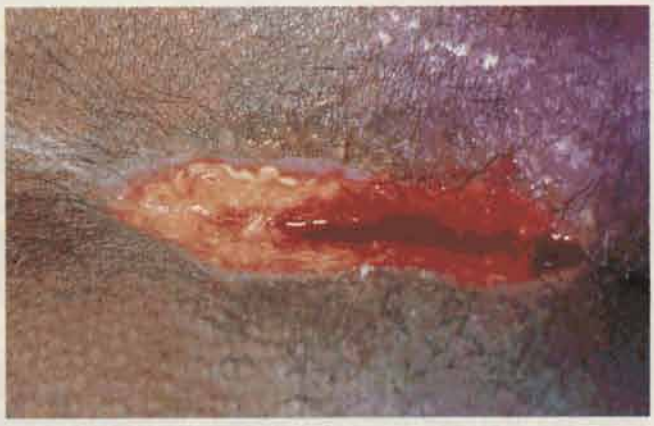

Fig 2. Wound with friable granulation tissue that bleeds easily

pressing the suspected infected tissue with a wound swab and eliciting a painful response from the patient.

Pocketing at the base of a wound

This occurs at the deepest part of a wound (Fig 4). In a prospective study of 100 pilonidal sinus excisions healing by open granulation, it was found that, in a sub-group of 30 wounds not receiving any antibiotic treatment, there were 10 wounds that formed pockets in their base[25]. According to the authors, this pocketing was 'apparently due to islands of infection which hold back new granulation tissue'. They recommended draining of these pockets.

Bridging of soft tissue and the epithelium

This may also be included in the criteria if complete epithelialisation is prevented owing to bacteria retarding the growth of new skin/tissue (Fig 5). In some instances the new epithelium will be complete and will give the appearance of a healed wound, but this will be of a bluish colour and will be fragile. This leads to an increased risk of early wound breakdown.

Odour

The smell of a wound can sometimes offer information that will be of use when attempting to identify wound infection (Fig 6). A healthy wound has a faint, but not unpleasant, odour akin to fresh blood. Infections by some aerobic organisms, such as staphylococci and streptococci, do not alter this. Infections owing to Gram-negative bacilli usually result in a distinctive and slightly unpleasant smell. Infections by anaerobic bacteria mostly produce an offensive odour — acrid or putrid[29]. In abdominal surgery a faecal smell may suggest a communicating fistula with the bowel.

Wounds containing necrotic material may have a repulsive and pervading odour owing to putrefaction, because of a mixture of anaerobic organisms and Gram-negative bacilli such as proteus. This species' unpleasant odour may cause the patient social problems[30]. Although acuity of sense of smell varies in different people, this examination should not be omitted. The odour of a wound may, of course, be modified by agents recently applied to it.

Wound breakdown

This may occur in an infected wound owing to micro-organisms weakening the repaired tissue[31] (Fig 7). This may be explained by the alteration of structure, or the alignment of collagen, with that produced at the site of repair. It also has been observed that wound breakdown may occur if the patient has been unduly active, and has put unnecessary stress on the healed wound that the newly formed tissue is unable to tolerate.

Conclusions

There are criteria available in addition to those traditional ones that may assist in the detection of infection in granulating wounds. By considering the clinical appearance of a wound and not delaying intervention in waiting for results of laboratory tests, treatment can take place

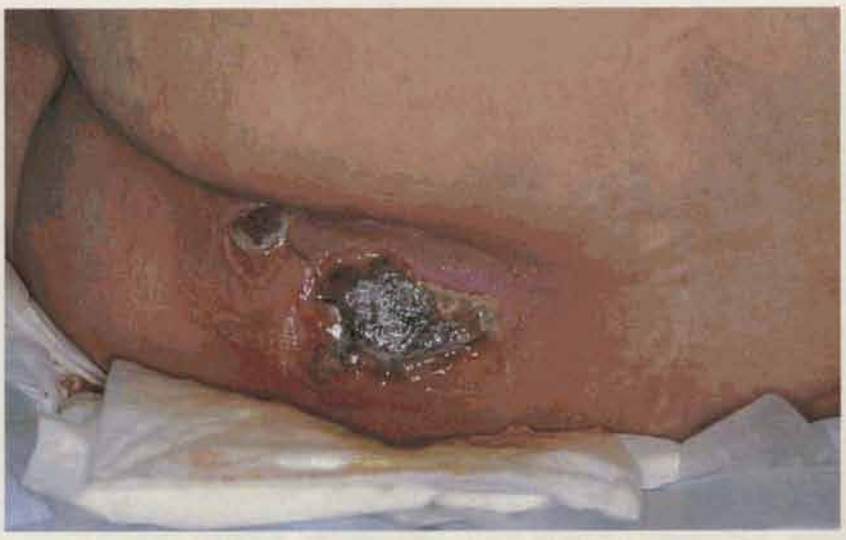

Fig 3. Pain may be caused by local swelling

Fig 4. Pocketing at the base of the wound

and wound healing may well be promoted. There is, however, a need to use a bacteriological swab to confirm the clinical suspicion of infection indicated.

Validation of these suggested criteria is required. In preference, this would be undertaken by the culturing of wound biopsy specimens as opposed to surface wound swabbing, which may identify only surface colonisation and not invasive organisms.

Observant, inquiring and skilful clinicians who use their eyes, ears, sometimes their noses and who have 'suspicious minds', should be assisted in recognising infection by using the above criteria. It is important that a flexible, intuitive approach is used and that our thinking relating to infection is not governed by rigidity or ritual. As our knowledge progresses the criteria presented here will no doubt undergo revision. It is also important to remember at this stage that the type of wound, any underlying disease and the type of dressing used will all affect the appearance of the wound.

It is appreciated that, although the above presentation may promote discussion and assist the practitioner in identifying infection in granulating wounds, there is no substitute for practical experience under the guidance of a skilled mentor. ■

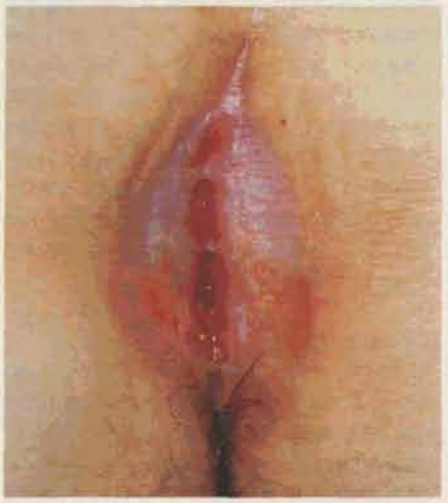

Fig 5. Bridging of soft tissue and the epithelium

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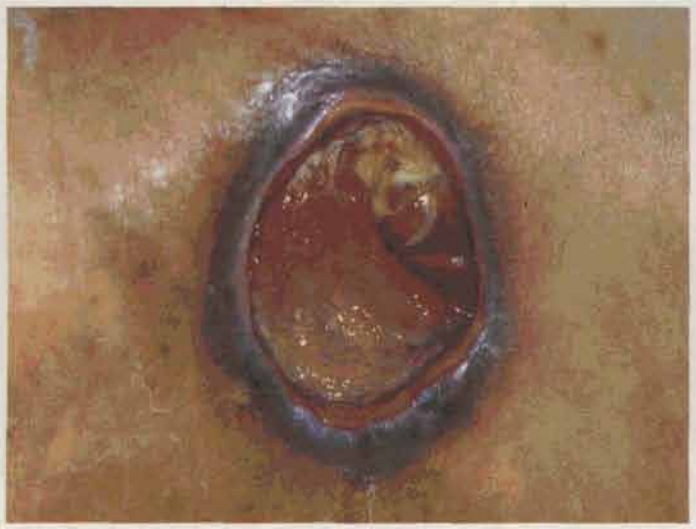

Fig 6. Odour may indicate anaerobic bacteria

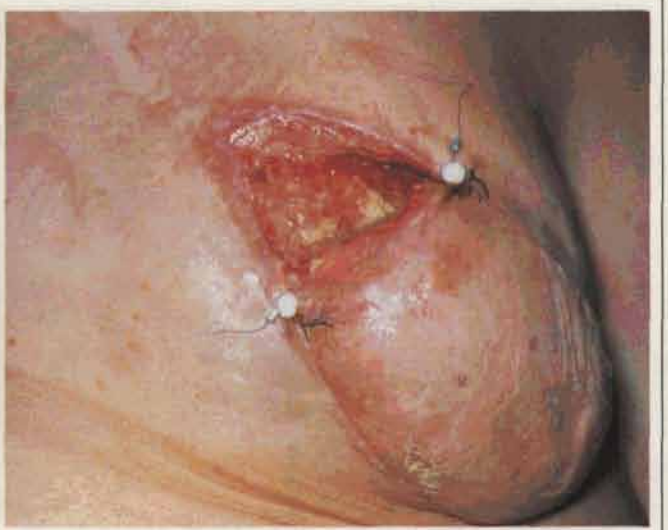

Fig 7. A wound that has broken down