# Guide to Caesarean Wound Healing

## British Journal of Midwifery, British Journal of Hospital Medicine supported by Smith and Nephew

**First draft deadline:** 17 March 2021

**Word count:** 2 400 - 3 000 words

**Objective**

This ‘Guide to’ will provide practical recommendations for midwives and obstetricians on the subject of caesarean wound healing.

To be inserted into the *British Journal of Midwifery and The British Journal of Hospital Medicine* the guide will comprise 6/8 pages with a front and back cover. The guide will include text, graphics and tables. The text should be fully referenced.

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## Content

### Intro

This guide presents practical recommendations for midwives and obstetricians on the subject of wound healing; specifically, in relation to surgical site infections (SSI) post caesarean section (CS) using negative pressure wound therapy (NPWT) for at risk groups .

### Section 1

It is well documented that there has been a steady growth in CS rates since the 1980s (Betrán et al, 2016) despite the World Health Organisation’s (WHO) reiteration since 1985 of an ‘ideal’ CS rate globally of 10-15% (WHO, 2015). Bragg et al (2010) asserts a CS increase in England from 9% in 1980 to 24.6% by 2008-2009. The National Maternity and Perinatal Audit (NMPA) Project Team (2019) reports a birth rate of 700,000 during 2016-17 in the UK National Health Service (NHS) across England, Wales and Scotland, of which approximately one in four women were delivered by CS (Bhatia et al, 2021). WHO (2015) affirms that when medically necessary, CS prevents maternal and newborn mortality (Sandall et al, 2018; Boerma et al, 2018). There are many speculated reasons for this increase such as rising maternal age at first pregnancy (Rydahl et al, 2019), technological advances and safety with CS (Xia et al, 2020), changes in women’s preferences (Betrán et al, 2018), tokophobia (Weaver et al, 2012) and women with a history of previous CS (Fobelets et al, 2018). Bragg et al (2010) remind readers of the need to take care when comparing data across NHS Trusts within the whole of the UK because the characteristics and nuances of practices vary considerably even when adjusting rates of CS.

CS is carried out during an emergency (category 1-2 (NICE, 2011)), as expedited (category 3 (Levy, 2006)) or as planned/elective (category 4 (Levy, 2016)). Since approximately 2014 there has been a growing trend towards Enhanced-Recovery (ER) after Planned CS Pathways (Abell et al, 2014; Kitson-Reynolds and Rogers, 2017; Pravina and Tewary, 2021) to enable quick recovery from surgery by preparing in advance for early ‘normalisation’ through a reduction in length of stay (Wrench et al, 2015). NICE (2011), updated in 2019, suggest that hospital stay could be an average of 3-4 days but with the possibility of discharge after 24hours if no signs of complications as this would not be associated with maternal readmissions to hospital. This confirms the findings from ER data (Bowden et al, 2019). Bhatia et al (2021) validates the continuation of CS during the Covid-19 pandemic, but what is not yet articulated is the impact of the pandemic and changes to postnatal home, online, telephone and remote visits across the NHS on potential CS wound infection rates.

The NHS (2019) website states that post CS wounds will be covered with a dressing for a period of 24 hours with advice as figure 1. NICE (2019) recommend the use of an ‘interactive’ (p12) dressing that will actively promote wound healing when left insitu as indicated through a ‘continuous assessment process’ (p15). There is no advice listed within the webpage on the signs of infection therefore it may be assumed that women will know what these are, know how to search for signs of infection via the internet, or will contact their midwife or appropriate health care professional for advice. Whilst the latest MBRRACE (Kenyon et al, 2020) report highlighted under ‘other causes of maternal death up to six weeks after pregnancy’ that infection attributed to 10%, it was linked to sepsis specifically rather than a causal link to post CS infection. One must remain mindful to the causes of sepsis and risks that CS pose potentially.

Figure 1: NHS (2019) and NICE (2011) CS wound care advice

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| * removing the dressing 24 hours after the CS (NHS and NICE) * gently cleaning and drying the wound daily (NHS and NICE) * wear loose, comfortable clothes and cotton underwear (NHS and NICE) * take a painkiller if the wound is sore – for most women, it is better to take paracetamol or ibuprofen (but not aspirin) while you are breastfeeding (NHS) * watch out for signs of infection (NHS)/specific monitoring for fever (NICE) * assessing the wound for signs of infection (such as increasing pain, redness, or discharge), separation or dehiscence (NICE) * if needed, planning the removal of sutures or clips (NICE) |

The CS procedure is not without risk and post-operative complication including infection (Sandall et al, 2018). For example, obesity increases not only a risk in favour of CS birth, but also surgical site infection (Tuuli et al, 2020). When considering the ‘wound’, it is imperative to be mindful of the layers of trauma involved in the CS with the external wound only visible (Denison et al, 2018). NICE (2011) set out best practice guidance on the closure of the uterus, peritoneum, abdominal wall, and closure of subcutaneous tissue (NICE, 2019) to account for increased maternal satisfaction with less pain, minimise risk of hernia, dehiscence and wound infection (Wall et al, 2003). To minimise the risk of infection women are offered prophylactic antibiotics (Childs et al, 2019); effective against endometritis and urinary tract infections (NICE, 2011). There appears to be a consensus that the skin should be closed with sutures in priority to staples to reduce the risk of ‘superficial wound dehiscence’ (NICE, 2019) although the evidence is lacking for all populations (section 3).

Wound healing is a complex process (Li et al, 2007; Singh et al, 2017; Velnar et al, 2009) comprising a ‘cascade of biochemical events’ (Lofrumento et al, 2017; p125) to repair trauma. Wound healing time can be diverse with some wounds taking up to a year to fully heal (Velnar et al, 2009) with a similar structure. CS healing includes a uterine wound which involves many cells such as ‘endothelial cells, neutrophils, monocytes/macrophages, lymphocytes, fibroblasts, myometrial cells as well as stem cell population found in the myometrium’ (Lofrumento et al, 2017; p125). Healing can be divided into several continuous and overlapping processes (fig 2).

Figure 2: wound healing processes and timings

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| Wound healing processes | Timings |
| Coagulation and haemostasis | Commences immediate after injury |
| Inflammation | Commences shortly after injury |
| Proliferation | proliferation within days of the injury |
| Wound/tissue remodelling with scar tissue formation | strengthening may take up to a year or more |

[Add in diagram 1 from excel]

Diagram 1 presents the complex intrinsic pathway of clot formation and dissolution in the non-pregnant healthy human (Sherwood, 2015). Pregnancy is an acquired hypercoagulable state (Tucker-Blackburn, 2003). Tissue factor III (thromboplastin) is found in amniotic fluid, deciduous and endometrial stroma. The soluble fibrinogen complexes are increased. During pregnancy smooth muscle and elastic tissue within the uterine spiral arteries are replaced by a fibrin matrix to facilitate increased expansion in blood flow to the placenta and facilitate the collapse of the terminal portion of vessels in placental separation. Surgical incision results in bleeding, vessel constriction with coagulation, activation of complement and an inflammatory response (Li et al, 2007). Acute surgical wounds act to initiate an extrinsic pathway to clot formation starting at the point of tissue thromboplastin factor III missing out some stages of the clot cascade as seen in diagram 1 (Sherwood, 2015).

### Section 2

Wound infections are not uncommon (Childs et al, 2019). A plethora of evidence highlights that surgical site infections (SSI) cause substantial maternal morbidity and mortality (Salim et al, 2012; Shiroky et al, 2020; Rubin, 2006; Zuarez-Easton et al, 2017; Schneid-Kofman et al, 2005; Wloch et al 2012; Childs et al, 2019; El-Achi et al, 2018; Gibbons et al, 2011). SSI within 30 days is one of the most common complications following CS with an incidence on 3-15% (Corbett et al, 2021; Zuarez-Easton et al, 2017; Saeed  et al, 2017) and a maternal mortality rate of up to 3% (Zuarez-Easton et al, 2017). With the duration of in-patient stay post-caesarean reducing, monitoring for SSI presents a challenge (Rubin, 2006). Petherick et al’s (2006) systematic review suggests having a standardised definition of wound infection would support surveillance of SSIs however Gibbons et al (2011) suggest this may not be feasible due to variance in surveillance programmes and NHS Trusts. A fresh eyes perspective (Paeglis, 2012) on the evidence base surrounding contemporary surgical practices including a review of prophylactic antibiotic therapy and maternal comorbidities may help to reduce SSI rates at local levels (Zuarez-Easton et al, 2017). Rubin (2006) formulates the risk factors within three categories (table 1).

Table 1: Rubin’s (2006) risk factors leading to potential surgical site infection as applied to contemporary context

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| Rubin’s (2006) risk factor categories | Examples of risk | Supporting evidence |
| host-related factors | * maternal older or younger age * obesity * pregestational diabetes mellitus * previous caesarean delivery * recurrent pregnancy loss * maternal preoperative condition | Krieger et al (2016 )  Zuarez-Easton et al (2017)  Wloch et al (2020)  Schneid-Kofman et al (2005) |
| pregnancy and intrapartum related factors | * hypertensive disorders * gestational diabetes mellitus * twin pregnancy * preterm rupture of membranes * greater number of vaginal examinations * prolonged trial of labour prior to surgery * epidural use * use of internal fetal monitoring * chorioamnionitis * increase in induction of labour | Schneid-Kofman et al (2005)  Krieger et al (2016)  Schneid-Kofman et al (2005)  The NHS Patient Survey Programme (2020) |
| procedure related factors | * operator staff grade * emergency setting * non-use of prophylactic antibiotics * uterine rupture * caesarean hysterectomy * need for blood transfusion * surgeries of longer duration | Wloch et al (2020)  El-Achi et al (2018) |

Wloch et al’s (2012) multicentre cohort study across 14 NHS hospitals in England, identified high rates of postsurgical infection following CS (9.6% n=394/4107) with 0.6% (n=23/4107) requiring readmission for treatment. El-Achi et al (2018) undertook a retrospective study to identify incidences and characteristics for readmissions post CS. They concluded a readmission rate of 2.6% (n=165/6334) of which 25.5% (n = 42) were for SSI. The most common reason for SSI readmission liked to women who had experienced emergency CS and had a co-morbidity predisposing them to infection. Gibbons et al (2011) caution against interpreting percentages of SSIs across organisations and countries as it is not reflective of the quality of care provided. Individual organisations should review their internal statistics to identify any lessons learned (Corbett et al, 2021; Carter et al, 2017) and any need to adjust current surveillance methods (Petherick et al, 2006). The implication being that with increasing CS rates (WHO, 2015; Bragg et al, 2010) there will inevitably be a parallel cost incurred not just financially (Zuarez-Easton et al, 2017; Bullough et al, 2014) attributed to treatment and management of SSI (Wloch et al, 2012), but on clinical workloads (Corbett et al, 2021; Carter et al, 2017) and for the woman and her family (Zuarez-Easton et al, 2017; Wloch et al, 2012). Wloch et al (2020) guesstimated 2019 prices to be around £5.0 m for all caesarean sections performed annually in England 2018–2019 with a cost of approximately £1866 per infection in hospital and £93 per infection managed in community. These were based upon costings and predictions back in 2010 and are therefore likely to be more of a financial burden, such as demonstrated in Bullough et al (2014).

### Section 3

The breadth of evidence suggests the biggest increased risk to SSI post CS is obesity (Salim et al, 2012; Childs et al, 2019; Krieger et al, 2016; Zuarez-Easton et al, 2017; Wloch et al, 2012; Schneid-Kofman et al, 2005; Sebire et al, 2001; Dias et al, 2019; Tuuli et al, 2020) with rates ranging between 3% and 30%, depending on the definition used for SSI, length of follow-up and the population (Dias et al, 2019). Obesity is also linked with other co-morbidities such as pre-eclampsia and gestational diabetes that are likely to impact upon wound healing (Schneid-Kofman et al, 2005; Wall et al, 2003). Of the women in El-Achi et al’s (2018) study with SSI, 69% were deemed overweight and 14% had diabetes. Dias et al’s (2019) retrospective cohort design using case notes, in two hospitals in Scotland considered severe obesity being women with a body mass index (BMI) >40kg/m2 showed that lower maternal age and being a current smoker was predictive of SSI. Longer wound open times marginally increased the chance of SSI. Other independent risk factors for an early wound infection include hypertension, premature rupture of membranes, emergency caesarean delivery, and twin delivery (Schneid-Kofman et al, 2005). Many factors are known to adversely affect healing including malnutrition, hypoxia, immunosuppression, chronic disease, and surgery (Singh et al, 2017; McLean et al, 2012).

The Royal College of Obstetrics and Gynaecology (RCOG) (Denison et al, 2018) advocates that women with obesity undergoing CS should receive prophylactic antibiotics at the time of surgery as Smail and Grivell’s (2014) systematic review, comprising 82 studies and 14407 women, showed that by doing so, the incidence of wound infection was reduced (RR 1.40, 95%CI 0.35-0.46). Women with more than 2 cm subcutaneous fat should have the subcutaneous tissue space sutured (NICE, 2011) to minimise infection and wound separation (Dennison et al, 2018).

### Section 4

It is clear from the evidence in the previous section 3 that obesity is the biggest risk contributing to SSI following CS and can be planned for. There are several studies evaluating the effectiveness of treatments to alleviate symptoms of infection to promote wound healing (Shiroky et al, 2020; Norman et al, 2020) and prophylactic interventions to minimize SSI prior to the surgery for women deemed to have a risk factor (De Vries et al, 2016). Whilst the use of negative pressure wound therapy (NPWT) (fig 3) appears to be widely used and accepted for general closed surgical incisions (De Vries et al, 2016), what is less clear its application for SSI following CS (Norman et al, 2020; Kawakita et al, 2021). There is uncertainty as to how NPWTs exactly work to support wound healing however, NPWT in the management of high-risk patients with closed surgical incisions can positively reduce bacterial contamination, oedema, haematoma, seroma, and suture line tension (Stannard et al, 2012) and increase microvascular blood flow and promote the formation of granulation tissue. Studies have reported that there is a lack of good-quality evidence to recommend the routine use of NPWT (Stapleton, 2015; Tuuli, 2019; Dennison et al, 2018), barrier retractors (Childress et al, 2016; Dennison et al, 2018) and insertion of subcutaneous drains (Dennison et al, 2018) to reduce the risk of wound infection in obese women requiring CS.

Figure 3: Explanation of Negative Pressure Wound Therapy (NPWT)

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| PICOTM (Smith and Nephew) is a single use negative pressure wound therapy portable system “designed to allow an even distribution of negative pressure on the surface of a closed surgical incision” NICE (2019a; p 5-6). It is designed to manage up to 150ml of exudate when left insitu for a week, as per the manufacturer instructions. It is an easy to apply dressing with a small pump that can be easily portable in the patient’s pocket |

Stapleton (2015) and Sandy-Hodgetts et al (2020) affirm that NPWT has become increasing popular in Australia for high-risk population CS wounds. Stapleton (2015) secured funding for a RCT comparing clinical and economic outcomes between typical wound dressings and PICOTM NPWT of 2000 women undergoing CS in each of four Queensland maternity hospitals. Sandy-Hodgetts et al (2020) propose a parallel group randomised control trial with 448 women across two metropolitan hospital in Perth Australia to investigate the effectiveness of negative pressure wound therapy in the prevention of surgical wound complications in the CS at-risk population.

Hyldig et al’s (2019; 2019a) multi-centre RCT in Denmark highlighted SSI in 20 (46%) women treated with NPWT compared to 41 (9.2%) women treated with a standard dressing (relative risk 0.50, 95% CI 0.30–0.84; number needed to treat 22; P = 0.007) but showed no difference in long-term cosmetic outcomes (Hyldig et al, 2020) akin to findings by Kawakita et al (2021). The population were young obese women with no other co-morbidities which is not comparable to other studies of this ilk. The cost effectiveness of NWPT was seen in those women who had a pre‐pregnancy BMI ≥35 kg/m2 but not significant in those women outside of this range. Tuuli (2019) and Kawakita et al (2021) assert that current data reflects small RCTs and retrospective cohort studies with small sample sizes and selection bias that may be confusing to the reader. Tuuli et al (2020) conducted their own multi-centre RCT across four academic and two community sites in the USA with 1624 women randomised to NPWT or standard wound dressings. They conclude that the prophylactic use of NPWT compared to the standard wound dressing did not significantly reduced the risk of SSI amongst obese women undergoing CS meaning that they could not recommend supporting routine use of NPWT in this way. This conclusion is mirrored by Dennison et al (2018) in the RCOG green top guideline whereby there is a lack of good quality evidence. However, individual NHS Trusts have presented quality improvement projects or audits of changes to practice that have shown positive impact on the reduction of overall infection rates by simply moving from a standard dressing to a NPWT for patients undergoing CS with a high BMI, in particular the single use PICOTM (Smith and Nephew, n.d.) NPWT dressing (Bullough et al, 2014; Searle and Myers, 2017).

Having affirmed this, NICE (2019a) state the case to support the use of PICOTM NPWTs as an option for NHS patients at risk of SSIs for closed surgical incisions. They base this national guidance crucially on the synthesis of 31 globally conducted studies; 15 of which were RCTs covering a range of surgical interventions not just specific to CS. The clinical evidence that NPWTs lead to less SSIs (Norman et al, 2020) when compared to standard wound dressings and that these NPWT provide extra clinical benefits at comparable costs remains national best practice recommendation. Bullough et al (2014) calculated the cost effectiveness of the use of PICOTM against the standard wound dressing resulting in a cost saving of £29,449 per annum based on 65 CS per month and a readmission rate of up 3 women per month.

### Section 5

The impact of SSI post CS for a woman and her family is considerable as post CS recovery is much slower with women experiencing pain (Stapleton, 2015), fatigue (Sandall et al, 2018), a reduction in breast feeding (Sandall et al, 2018) and psychological impact on mother-infant attachment (Gross, 2005). As with all best practice recommendations, enhanced outcomes are met through a multi-disciplinary (MDT) approach through audit, service evaluation, quality improvement projects, fresh changes to current practices in collaboration with the service users (Nursing and Midwifery Council (NMC), 2018; NMC 2019). Bullough et al (2014) highlighted a gap in the knowledge base of midwives generally around post-operative wound care, inadequate post CS wound management and a lack of ownership relating to wound care. The key to minimising SSI is recognition of poor healing, the start of an infection (Sartelli et al, 2017) and a better knowledge of wound dressing efficacy. This is compounded by the fact that services have temporarily/semi-permanently reconfigured postnatal services acknowledging Covid-19 with minimal physical contact. Enhancing education around wound care for all staff and the provision of quality evidence-based patient information will support a reduction in SSI (Bullough et al, 2014) with a potential cost/resource reduction of a decrease in the incidence of wound infection. For example, the use of antimicrobial products and antibiotics, GP consultations, district nursing and outpatient visits could all potentially be reduced.

### Summary

There is an expanding evidence base recommending the use of PICOTM NPWTs for reducing SSI on women with a BMI ≥35 kg/m2. This evidence base is deemed to be limited due to the small sample size, selection bias and confounding factors. Further research is required such as a large multi-centre RCT along with qualitative research to understand the experiences of both women and MDT who have used PICOTM NPWTs for SSI. Until then, NICE (2019a; 2019) guidance continues to recommend the use of PICOTM for women undergoing CS in the at-risk group.

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