Should I drain this abscess? The imaging appearances of haemostatic surgical packing materials both in vivo and in vitro

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Learning objectives

1. Become familiar with common types of bioabsorbable haemostatic materials used in abdominal surgery, such as TachoSil®.
2. Relate the in vitro appearance of haemostatic agents to their subsequent activated in vivo forms on CT.
3. Appreciate that these substances may mimic an abscess on post operative CT.
4. Be aware of some features that may help distinguish bioabsorbable haemostatic materials from an abscess on post operative abdominal CT, and thus help avoid unnecessary intervention.

Background

A variety of intra operative techniques may be used to minimise blood loss during surgery. Mechanical methods such as ligation with sutures or clips, and thermal coagulation using diathermy, are widely used conventional techniques. However, they are not always appropriate depending on the site, type and distribution of bleeding vessels. For example, extensive cauterization results in tissue necrosis with a higher risk of infection and subsequent secondary haemorrhage from tissue breakdown.

Bioabsorbable haemostatic agents applied topically to vulnerable and challenging sites of bleeding, such as blood oozing from a liver abrasion or from suture holes around vascular anastomoses, provide a useful addition to conventional methods of haemostasis. They are used in a wide range of surgical procedures and body regions, including various abdominal, pelvic, vascular, neurosurgical, and orthopaedic operations.

Haemostatic agents are available in a variety of forms, such as a pad, sponge or glue-like material. Some are impregnated with, or require the addition of a pro-coagulant substance such as thrombin prior to their use, whilst others aid endogenous coagulation mechanisms by providing a collagen matrix to stimulate thrombus formation. They become fully activated upon contact with body tissues or fluids, particularly blood.

Haemostatic packing materials are designed to be left in the body and are absorbed or integrated into surrounding tissue over time. They have no radio-opaque marker to specifically identify them on radiographs or CT.
In contrast, non-absorbable gauze packing materials commonly used in surgery contain a radio-opaque ribbon or marker, to help identify them in case they are inadvertently left behind in the surgical field. They are not to be permanently left within the body, although large gauze packs may be deliberately and temporarily placed within the abdomen and pelvis to aid haemostasis, most commonly following extensive traumatic injury.

Activated haemostatic agents used in abdominal and other types of surgery, have been reported to mimic the appearance of an abscess on CT examinations performed in the first few weeks following surgery (Young et al., 1993, Sandrasegaran et al., 2005, Israel et al., 2006).

Misinterpreting haemostatic materials in the surgical field for a post operative abscess on abdominal CT, may lead to unnecessary and potentially harmful intervention, such as drain insertion or further surgery.

This exhibit aims to improve interpretation of post operative abdominal CTs by presenting both the photographic and CT appearance of three commonly used haemostatic agents, namely Surgicel®Fibrillar™, TachoSil® and FloSeal®, in their inactive and partially activated in vitro forms. This may improve detection of the in vivo appearance of such materials, and help understand why they may mimic an abscess. Examples of post operative abdominal CTs containing haemostatic agents are reviewed and compared to a post operative abscess, and their possible distinguishing features highlighted.

**Imaging findings OR Procedure details**

**Bioabsorbable haemostatic materials- in vitro appearance:**

A wide range of bioabsorbable haemostatic agents are available for use. They may be derived from collagen, gelatin, fibrin, cellulose, polysaccharide, inorganic or polymeric substances, and may have different mechanisms of action (Seyednejad et al., 2008). In addition to their haemostatic function, some have adhesive and antibiotic properties. Further details about the various types, configurations, and actions of haemostatic materials is beyond the scope of this radiological exhibit, however, three examples of haemostatic agents commonly used in our institution are discussed and illustrated.
Samples of Surgicel®Fibrillar™, TachoSil® and FloSeal® have been photographed in vitro before and after partial activation with a dextrose-saline solution. Subsequently, CT images of the samples were acquired using a Siemens Somatom Sensation 64 detector CT scanner, reconstructed at a 1.5mm nominal slice thickness, on standard abdominal and lung windows.

**Surgicel®Fibrillar™ (Ethicon, Inc., United States of America):**

Surgicel®Fibrillar™ (Ethicon) is one of the most versatile and commonly used absorbable haemostatic agents in our institution. This is a sterile soft layered material based on oxidised regenerated cellulose technology. It is available in various sizes, such as the 2.5cm by 5.1cm rectangle shown in Figure 1. The required amount can be pulled off by forceps or cut to size, and applied to the bleeding site and held firmly in place until bleeding ceases. It also has bactericidal properties in vitro against various organisms. It may be used in a wide range of operations to help control capillary, venous or small arterial haemorrhages.

Upon contact with fluid, Surgicel®Fibrillar™(Ethicon) swells, and becomes soft and gelatinous as shown in Figure 2. When applied directly to a bleeding point, this material becomes a blood-soaked gelatinous mass that helps clot formation by additionally acting as a physical barrier. It conforms and becomes integrated into the bleeding tissue. Despite being absorbable, any excess should be removed after haemostasis is achieved to aid absorption and minimise a foreign body reaction. Absorption of oxidised regenerated cellulose is thought to take 1-2 weeks but depends upon the site and amount used (Seyednejad et al., 2008).

The gelatinous mass formed by Surgicel®Fibrillar™ in solution as shown in Figure 2, has a fairly homogenous density on CT, on both abdominal (Figure 3) and lung windows (Figure 4), with no discernible gas-fluid level or trapped gas bubbles visible within it.

**TachoSil® (Nycomed, Austria):**

TachoSil® is a thin collagen sponge coated on one side with the human coagulation factors fibrinogen and thrombin. The yellow side of the sponge (see Figure 5), containing the impregnated coagulation factors, becomes activated upon contact with fluids such as blood or saline. The resultant fibrin network helps to adhere the active side of the sponge to the tissue surface, aiding the coagulation process and helping to seal the tissue.
This sponge is available in various sizes, such as the 9.5cm by 4.8cm rectangle shown in Figure 5, which has been cut to demonstrate both its sides. The yellow side containing the active ingredients is rougher in its dry form but becomes soft and conformable in solution (Figure 6). It also has multiple small craters on its surface, which increase its surface area for coagulation, but can also trap locules of gas \textit{in vitro} (Figure 5) and \textit{in vivo} as illustrated in the cases shown later in Figures 10 to 15. The gas locules in the \textit{in vitro} samples were best appreciated on lung windows (Figure 7), and were not well seen on standard abdominal windows, hence not shown.

TachoSil® sponge can be cut to size and used in a variety of surgical procedures. It has more structural integrity than Surgicel® Fibrillar™ (Ethicon). In our institution, it is most commonly used in hepatobiliary surgery, as it can be placed on liver resection margins or in the pancreatic resection bed to aid haemostasis.

\textbf{FloSeal® Hemostatic Matrix (Baxter International Inc., United States of America):}

FloSeal® is a high viscosity haemostatic gel that has to be prepared at the time of surgery. It is available as a kit which requires a bovine-derived gelatin matrix, consisting of cross-linked gelatin granules, to be mixed with a human thrombin solution. The gelatin matrix and thrombin solution are mixed by transferring them back and forth between two syringes as shown in Figure 8. When mixed with a dextrose-saline solution, FloSeal® gelatin granules resulted in a slightly heterogeneous appearance on CT abdominal windows (Figure 9). No trapped gas locules or other specific appearance was seen on lung windows, hence not illustrated.

FloSeal® may be used in a wide range of surgical procedures to aid haemostatic control. It can be injected from the syringe using an applicator directly onto wet, bleeding tissue. However, it must not be injected into blood vessels due to the risk of intravascular coagulation. Any excess FloSeal® not integrated within the formed haemostatic clot should be removed. FloSeal® Matrix typically takes 4-6 weeks to be absorbed \textit{in vivo} (Seyednejad et al., 2008).

\textbf{Bioabsorbable haemostatic materials- \textit{in vivo} appearance:}

Most \textit{in vivo} haemostatic materials are absorbed in 2 to 8 weeks, depending on the type, site and amount used. However, on CT examinations performed before these materials have fully blended with the tissues in the operative site, they may mimic a post operative abscess (Sandrasegaran et al., 2005). Misinterpreting a haemostatic agent undergoing absorption for an abscess has significant clinical implications, as it may result
in unnecessary and potentially harmful intervention, such as antibiotic therapy, attempted drainage or further surgery.

If a retained haemostatic material is not fully absorbed over time or induces a strong foreign body reaction with associated chronic inflammation, it may result in the formation of a granuloma, which may mimic other pathologies such as a tumour (Tomizawa, 2005).

Sandrasegaran et al (2005) reviewed post operative abdominal CTs on thirteen patients in whom a gelatin-based haemostatic sponge called Gelfoam® (Pharmacia) had been used. They have suggested that the following features are more in keeping with in vivo haemostatic gelatin sponge rather than an abscess on CT:

• Tightly packed gas bubbles of uniform size within the sponge
• Linear arrangement of gas bubbles that do not alter in position on serial CTs
• No discrete dominant bubbles
• No intervening fluid or soft tissue density between the gas pockets
• Geometric shape of the sponge

In our in vitro assessments, the appearances of Surgicel®Fibrillar™ and FloSeal® partially activated in dextrose-saline solution were rather non-specific on CT. However, the CT appearance of activated TachoSil® was very striking on lung windows (Figure 7), as the collagen-based sponge material trapped multiple gas locules within it, without any associated gas-fluid level. This feature may help in some cases to differentiate in vivo TachoSil® sponge in the surgical field from a post operative abscess.

Post operative abdominal CT images of 4 patients in whom haemostatic TachoSil® sponges were used are illustrated, and the in vivo CT features of these materials are highlighted and compared to a typical abscess.

Figures 10 and 11 illustrate the case of a patient who had undergone a difficult open cholecystectomy in which a 9.5cm by 4.8cm TachoSil® sponge had been used to assist with haemostasis in the gall bladder fossa. Three days after surgery, he underwent contrast-enhanced CT examination. This showed a soft tissue mass in the gall bladder fossa encircled by small tightly packed gas bubbles of uniform size in an orderly arrangement. No gas-fluid levels or peripheral enhancement typical of an abscess were observed. These findings represent the in vivo CT features of activated TachoSil®, which reflect the in vitro CT appearance of partially activated TachoSil® shown earlier in Figure 7, with multiple, uniformly arranged trapped gas bubbles. These features are very similar to those observed with in vivo Gelfoam® and described by Sandrasegaran et al (2005).

Similar CT features are observed in the case illustrated in Figures 12 and 13, in which TachoSil® was applied to a pancreatic resection margin. CT six days later shows
uniformly arranged gas bubbles around a soft tissue mass in the pancreatic resection bed, representing the haemostatic material.

Figures 14 and 15 illustrate another case with tightly packed gas bubbles in a linear fashion, with no dominant gas bubbles or associated gas-fluid levels, corresponding to three TachoSil® sponges that had been placed at the resection margin of the pancreatic head.

In the cohort of surgical patients we reviewed, no specific in vivo CT features were observed post operatively that could be used to distinguish the presence of Surgicel®Fibrillar™ or FloSeal® haemostatic materials used intra-operatively from a post operative abscess, hence in vivo examples of these two agents have not been shown.

Absorption of most haemostatic materials, under normal healing conditions, occurs within 8 weeks. Figures 16 and 17 demonstrate CT views 9 days following a right hepatectomy for colorectal liver metastases. Five TachoSil® sponges had been applied to the hepatic resection margin intra-operatively, and can be identified by their tightly packed and linearly arranged gas bubbles on these views. A re-staging abdominal CT 63 days post operatively demonstrates resorption of the linear gas bubbles seen in the hepatic resection bed (Figure 18), corresponding to absorption of the TachoSil® sponges at that site.

In contrast to haemostatic materials, abscesses on CT typically show scattered gas bubbles of varying sizes with large dominant bubbles, peripheral enhancement of the abscess wall and gas-fluid levels (Figure 19). It would be very unusual for the gas pockets of an abscess to maintain their position on subsequent CTs.

It is important to be familiar with normal or acceptable CT appearances following abdominal surgery, such as those relating to haemostatic materials. Knowledge of the types and uses of these haemostatic agents may help avoid mistaking them for a gas producing abscess on post operative CT, and prevent unnecessary and potentially harmful intervention.

For example, if haemostatic material around a prosthetic aortic graft is mistaken for a potential abscess on a post operative CT and drainage is attempted, in addition to the usual risks of intervention, the prosthetic graft would be exposed to a greater risk of infection and subsequent serious complications.
However, the presence of haemostatic materials in a surgical bed does not preclude abscess formation at that site. In fact, any fluid collection, haematoma or foreign material, including absorbable haemostatic agents have the potential to become infected, and may have a non-specific appearance on CT. Unusual gas collections in the surgical bed of septic patients who have had haemostatic materials applied may still require aspiration and antibiotic therapy to exclude an abscess.

Therefore, certain CT features such as tightly packed small gas bubbles in a uniform and linear configuration around a soft tissue density, may help distinguish some haemostatic materials in a surgical bed from a gas producing post operative abscess. However, the ultimate decision to intervene depends upon the clinical scenario and relies upon detailed communication between the surgeon and the radiologist.

Images for this section:
**Fig. 1:** Surgicel®Fibrillar™ (Ethicon) in vitro dry form. This photograph depicts the dry inactive substance.

**Fig. 2:** Surgicel®Fibrillar™ (Ethicon) in vitro wet form. This photograph demonstrates the partially activated haemostatic agent in a dextrose-saline solution, forming a gelatinous mass.
**Fig. 3:** Surgicel®Fibrillar™ (Ethicon) in vitro wet form on CT abdominal windows.
Fig. 4: Surgicel®Fibrillar™ (Ethicon) in vitro wet form on CT lung windows.
**Fig. 5:** TachoSil® (Nycomed) in vitro dry form. This photograph shows the dry sponge cut to illustrate both its sides. The yellow side (shown on the right) contains the active ingredients and has multiple craters on its surface.
Fig. 6: TachoSil® (Nycomed) in vitro wet form. This photograph shows both sides of the sponge, partially activated in dextrose-saline solution, which has softened its texture. The yellow side has retained its multiple small surface craters.
Fig. 7: TachoSil® (Nycomed) in vitro wet form on CT lung windows. This axial CT image shows that the partially activated sponge in dextrose-saline solution has a heterogeneous appearance on CT, containing multiple locules of gas. These trapped gas locules are most likely the result of the multiple small craters present on the sponge surface, as shown in Figures 5 and 6.
**Fig. 8:** FloSeal® (Baxter) in vitro preparation. Using the two syringes and accessories provided the gelatin granules forming the matrix are mixed with the thrombin solution.
**Fig. 9:** FloSeal® (Baxter) gel in vitro in a dextrose-saline solution on CT. On abdominal windows, the thrombin-infused gelatin granules give the solution a slightly mixed attenuation appearance.
Fig. 10: TachoSil® sponge (Nycomed)- in vivo CT appearance in the gall bladder fossa 3 days following open cholecystectomy: axial view on abdominal windows. Note the orderly arrangement of small tightly packed gas bubbles all the way around the soft tissue mass in the gall bladder fossa, with no peripheral enhancement, gas-fluid levels or other features to suggest an abscess. This represents activated in vivo TachoSil® which has yet to be absorbed.
**Fig. 11:** TachoSil® sponge (Nycomed)- in vivo CT appearance in the gall bladder fossa 3 days following open cholecystectomy: coronal view on abdominal windows. Note the orderly arrangement of small tightly packed gas bubbles around the soft tissue mass in the gall bladder fossa, with no peripheral enhancement, gas-fluid levels or other features to suggest an abscess. This represents activated in vivo TachoSil® which has yet to be absorbed.
Fig. 12: TachoSil® sponge (Nycomed)- in vivo CT appearance in the pancreatic resection bed 6 days following a Whipple’s procedure for a pancreatic tumour: axial view on
abdominal windows. Note the uniform arrangement of gas bubbles in the pancreatic head resection bed, representing the haemostatic sponge at that site.
Fig. 13: TachoSil® sponge (Nycomed)- in vivo CT appearance in the pancreatic resection bed 6 days following a Whipple’s procedure for a pancreatic tumour: coronal view on abdominal windows. Note the uniform arrangement of gas bubbles in the pancreatic head resection bed (mid upper abdomen), representing the haemostatic sponge at that site.
**Fig. 14:** TachoSil® sponges (Nycomed)- in vivo CT appearance in the pancreatic resection bed 8 days following a Whipple’s procedure for a pancreatic head tumour: axial view on abdominal windows. Note the tightly packed gas bubbles in a linear fashion (mid abdomen), with no dominant gas bubbles or associated gas-fluid levels, corresponding to the 3 TachoSil® sponges placed at the pancreatic resection margin.
Fig. 15: TachoSil® sponges (Nycomed)- in vivo CT appearance in the pancreatic resection bed 8 days following a Whipple's procedure for a pancreatic head tumour: coronal view on abdominal windows. Note the tightly packed gas bubbles in a linear
fashion (mid abdomen), with no dominant gas bubbles or associated gas-fluid levels, corresponding to the 3 TachoSil® sponges placed at the pancreatic resection margin.
**Fig. 16:** TachoSil® sponges (Nycomed)- in vivo CT appearance in a right hepatectomy resection bed 9 days following surgery: axial view on abdominal windows. The layers of linearly arranged and tightly packed gas bubbles in the subhepatic space anterior to the abdominal drain in situ correspond to the 5 TachoSil® sponges placed at the resection margin.
**Fig. 17:** TachoSil® sponges (Nycomed)- in vivo CT appearance in a right hepatectomy resection bed 9 days following surgery: coronal view on abdominal windows. The layers of
linearly arranged and tightly packed gas bubbles in the subhepatic space more medially correspond to the 5 TachoSil® sponges placed at the resection margin.
Fig. 18: Absorption of TachoSil® sponges (Nycomed) over time. Re-staging CT 63 days following a right hepatectomy for colorectal liver metastases: axial view on abdominal windows. The previously observed layers of linearly arranged gas bubbles in the hepatic resection bed, which corresponded to the intra-operative site of 5 TachoSil® sponges, are no longer visible indicating absorption of the haemostatic sponges.
Fig. 19: A typical intra-abdominal abscess on a post operative contrast-enhanced CT examination: axial view on abdominal windows. In the left iliac fossa of this septic patient, there is a large collection with an enhancing wall and multiple gas-fluid levels, in keeping with a post operative abscess. This was subsequently drained and proved to be infected.
Conclusion

Knowledge of the surgical technique and materials used intra-operatively may prevent misinterpretation of absorbable haemostatic materials for an abscess or other pathology, and help avoid unnecessary intervention.

Familiarity with the *in vitro* appearance of common haemostatic agents used in surgery, may improve detection of the *in vivo* appearance of these materials, and help distinguish them from a post operative abscess on CT.

Absorbable haemostatic materials such as TachoSil® sponge in a surgical bed are typically associated with tightly packed gas locules in a uniform linear arrangement, and unless there is co-existent infection, they do not generally exhibit peripheral enhancement or gas-fluid levels which typify an abscess.

Personal Information

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References

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