Removing a metal foreign object successfully from a patient's retroperitoneal space using laparoscopy and a novel navigation system

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ABSTRACT

Trauma with foreign objects retained within the human body has become a common surgical emergency condition. Traditional surgical methods often involve creating large incisions in soft tissue and may lead to additional complications during wound healing. We have developed a new method of removing foreign bodies from patients' abdomens by using laparoscopy with the help of a novel navigation system that provides accurate positioning. This approach is minimally invasive and simple. This is the first combination of both technologies in this field.

KEYWORDS

Foreign body – Laparoscopy – Navigation – Minimally invasive

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Introduction

With the rapid development of modern industrialisation, trauma with foreign objects retained within the human body has become a common surgical emergency condition.¹ Entry of a foreign object into a human body often causes various acute symptoms and/or chronic complications that may be life threatening, so attempts should be made to remove the object as soon as possible.^{2,5} Although foreign bodies in surface areas can be removed easily, those embedded deep inside the tissue are often difficult to remove. Traditional surgical methods often involve creating large incisions in soft tissue and may lead to additional complications during wound healing. Laparoscopic surgery is being increasingly used to remove foreign objects from the intraperitoneal and retroperitoneal regions particularly because there are fewer adverse effects from this minimally invasive technique.^{4,5}

The success of laparoscopic surgery often depends on accurate preoperative and intraoperative localisation of the foreign body. Commonly used localisation methods include conventional x-ray fluoroscopy,⁶ computed tomography (CT) guidance⁷ and ultrasound guiding.⁸ In this study, we report the use of a novel navigation system to identify the position of a foreign object accurately in a patient and the successful removal of the object from the retroperitoneal region by using laparoscopy.

The new navigation equipment we refer to as the 'surgical approach visualisation and navigation' (SAVN) system (Santan Medical Technology Limited Company, Hangzhou, China) was based on reuse of C-arm images. It has been reported to assist in the removal of foreign objects from any part of the human body.⁹ The equipment uses visible laser to simulate x-ray emission from the tube of the C-arm. When the x-ray passes through point a (Fig 1a) on the foreign object, it reflects as a' on the image amplifier (Fig 1a'). By choosing point a' on the image, analysis of the object is initiated by the navigation data processing module (Fig 1c) then the instruction is transmitted to the laser driver device installed on the image amplifier (Fig 1b) to move the laser transmitter (Fig 1d). This simulates x-ray emission from the tube that passes through point a on the object, thus allowing visualisation of the x-ray. The procedure is not complicated and requires the user to only follow directions and position the laser beam so that point a on the object in the body can be localised.

Case history

A 42-year-old male auto parts factory worker had one mechanical part shot into his abdomen during an accident more than one month prior to presentation. An initial emergency laparotomy conducted in another hospital reported the following intraoperative findings: stomach

perforation, mesenteric tear and bleeding, rupture of left posterior peritoneum and contusion of the lower pole of the left kidney. However, they failed to locate the foreign object. They then performed stomach repair, mesentery repair and left kidney contusion repair. When the patient came to our hospital, he had no complaints on admission. Physical examination showed the following: a temperature of 36.3 degrees C, pulse 72 beats/minute, respiration 18 breaths/minute, blood pressure 130/80 mmHg, oxygen saturation 100%. The abdomen was flat and the 2-cm long entrance wound of the foreign body was visible above the umbilicus. One 25-cm midline incision scar was also

visible. The abdomen was soft, with no tenderness or rebound tenderness, and bowel beep was normal, four times per minute. Percussion pain was positive in the kidney area. Routine blood tests revealed a white blood cell count of 5.62×10^9 , platelet count of 213×10^9 , haemoglobin 123 g/L. Preoperative abdominal plain film x-rays (Fig 2A,2B), CT scans (Fig 2C,2D), and three-dimensional computer reconstruction (Fig 2E,2F) showed the foreign body located on the left side of the retroperitoneal site.

Surgical procedures

Under general anaesthesia, indwelling catheterisation was conducted with the patient in a complete right lateral position. Disinfection and drape procedures used standard protocols. First, a 1.5-cm skin incision was made in the left mid-axillary line, 2 cm above the iliac crest. Blunt dissection of the muscle was conducted using haemostatic clamps and the retroperitoneal space was dissected with fingers to push aside the peritoneum. A 10-mm trocar was then inserted, followed by placement of a laparoscope at 30 degrees. Under visual inspection, the 5-mm and 10-mm trocars were placed into the anterior and posterior axillary lines, respectively, just under the costal margin. Retroperitoneal adipose tissue was then removed and the kidney was made free posteriorly close to the psoas major muscle plane. Extensive scarring was found at the retroperitoneal space.

After repair and fixing the left kidney, the posterior peritoneum was opened to locate gut adhesions and retroperitoneal fat. The SAVN system was then placed (Fig 3A) to display the position of the foreign body (Fig 3B). By

Figure 3 The surgical approach visualisation and navigation system is used to position the foreign object. A) placing the laser navigation equipment; B) foreign object under fluoroscopy (a) laser transmitter under fluoroscopy (b); C) visible red laser beam spot to position on the body surface; D) K-wire inserted along the position and direction of the laser beam

clicking the foreign body on the screen, the laser transmitter was triggered to emit a visible laser, which simulated x-ray emission through the foreign object (Fig 3C). One K-wire was inserted into the body along the direction of the laser beam (Fig 3D). Further insertion of the K-wire was done by monitoring through laparoscope to prevent damage to vital organs. Guided by the laser beam, the K-wire was accurately navigated to the foreign object, which was then separated from the retroperitoneal fibrous tissue (Fig 4). The object was removed through the incision at the posterior axillary line. Drainage tubes were placed beside the left kidney and fixed on the incision at the anterior axillary line. After checking incisions and the insertion sites, no bleeding was found. All trocars were then removed and each incision was sutured after counting the gauze and instruments (Fig 5A). The operation was completed successfully. Intraoperative blood loss was 50 ml with no requirement for blood transfusion during the

Figure 4 Laparoscopic surgery. A) K-wire showing the position of the foreign body; B) foreign body removed using forceps

Figure 5 The surgical wound (A) and the foreign object (B) after surgery

surgery. The foreign body was a $1.5 \times 1.5 \times 0.2$ cm button-shaped flat metal object, which was intact without rupture (Fig 5B).

Discussion

A foreign body usually causes some acute symptoms but sometimes does not cause any discomfort. As time goes by, metal erosion, foreign body granuloma and secondary injuries due to migration or even tumour development could occur.^{10–12} In addition, the residual foreign body can prevent the patient from having magnetic resonance imaging examination and will bring some psychological problems. Therefore, removal of the foreign body is the best option.

Here, we report the successful removal of a foreign object lodged into the retroperitoneal region from a patient using novel navigation equipment. Accurate positioning of the foreign body is key to its removal. Preoperative x-ray examination,¹³ CT, three-dimensional CT reconstruction¹⁴ and high-frequency ultrasound¹⁵ can provide important information to localise foreign objects lodged in a human body, so we also performed these preoperative examinations for this patient. It should be noted that changes in intraoperative posture, organ peristalsis and other factors, are likely to change the position of the foreign object. Therefore, an intraoperative real-time, accurate and visual positioning method is needed. Currently used methods include C-arm fluoroscopy, guidance using an ultrasound probe and metal detectors. However, these techniques have some disadvantages. For example, C-arm fluoroscopy provides only two-dimensional images, so repeat scanning is needed; ultrasound is often influenced by hollow organs, thus limiting localisation of the foreign object. The newly developed metal detector tool is currently available only in a few institutions.¹⁶ In addition to these methods, some surgical navigation systems have also been used, although these often require CT scanning and three-dimensional reconstruction, which may expose patients to large amounts of radiation and cannot reflect real-time conditions during surgery.¹⁷

In this surgery, we used a new type of navigation system: the SAVN system. This permitted high positioning accuracy (± 1 mm), which is required not only during the surgery for real-time precise positioning, but can also significantly reduce exposure of the patient and doctors to x-ray

radiation.⁹ This laser device does have some limitations. The visible laser does not penetrate the human tissue and therefore a K-wire is inserted into the body along the direction guided by the laser to assist navigation in deep tissues.

Our experience from this surgery was as follows:

- > There are many uncertainties during the removal of a foreign object from the human abdominal cavity with a number of potential complications to be handled simultaneously during the surgery. The surgeon must therefore be skilled in laparoscopic operation.
- > Correct selection of the incision sites depends on comprehensive preoperative examination and fine preoperative planning. The incision sites should be chosen away from the lesion to facilitate proper operating space.
- > The abdomen should be explored carefully and gently to avoid missing lesions or causing injury.
- > The indications for the laparoscopic operation should be strictly controlled to address safety and reliability. In cases where there are special conditions, such as unclear anatomy, or difficulty in exposing the operative field, the laparoscopic operation should be switched to conventional incision operation.

Conclusions

We have described a new method for the removal of foreign objects lodged in the retroperitoneal spaces of the human body. Laparoscopic surgery, used together with the new laser navigation equipment, could remove retroperitoneal foreign objects lodged in a human body accurately and quickly. This method could also be applied to remove intraperitoneal foreign objects. The laser navigation equipment could locate deeply lodged foreign objects accurately and the laparoscopic surgery was minimally invasive, resulting in fewer postoperative complications. Furthermore, the combination of these two techniques synergised their advantages and benefited both patients and doctors.

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