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Original research

Using methylene blue as a marker to find and remove tiny metallic foreign bodies embedded in the soft tissues of children: A randomised controlled trial

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HIGHLIGHTS

- The removal of tiny metallic foreign bodies by using methylene blue as a marker has several advantages.
- The method decreased operation time, incision length depth and minimize the risk of damage to the surrounding tissue.

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ABSTRACT

Background: Embedment of metallic foreign bodies in the soft tissues is commonly encountered in the emergency room. Most foreign bodies are easily removed, but removal is difficult if the foreign body is very small or deeply embedded.
Objective: To determine the usefulness of methylene blue staining in the surgical removal of tiny metallic foreign bodies embedded in the soft tissue.
Methods: This prospective study involved 41 children treated between May 2007 and May 2012. The patients were randomly divided into a methylene blue group and a control group. In the control group, foreign bodies were located using a C-arm and removed via direct incision. In the methylene blue group, foreign bodies were located using a C-arm, marked with an injection of methylene blue and then removed surgically. The clinical outcomes, complications, operation time, surgical success rate, incision length, frequency of C-arm use, and length and depth of the foreign body were compared between the two groups.
Results: The surgical success rate was significantly higher in the methylene blue group. The average operation time was significantly shorter in the methylene blue group. The C-arm was used significantly less frequently in the methylene blue group than in the control group. The incision length was significantly shorter in the methylene blue group than in the control group.
Conclusions: Methylene blue staining facilitated the location and removal of tiny metallic foreign bodies from the soft tissue, and significantly reduced operation time, incision length and radiation exposure compared to the conventional method.

1. Introduction

Foreign bodies can become accidentally embedded in soft tissues after penetrating or abrasive trauma, and may cause substantial discomfort, deformity, and complications. Embedment of metallic foreign bodies, such as sewing needles, shell fragments, and iron chippings, in the soft tissue is commonly encountered in pediatric patients in the emergency room. Most of these objects can be easily removed; however, the removal of objects that are too small or too deeply embedded can be difficult. Furthermore, there is no standard surgical procedure for removing metallic foreign bodies. Various types of equipment have been used to assist in foreign body removal, such as endoscopes [1–3], metal detectors

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[4–6], and magnets [7]. Recently, surgical navigation systems were used for foreign body removal [6,8–10], with very high success rates. However, these techniques require special equipment and are expensive. They also necessitate the frequent use of a C-arm during surgery, which exposes both surgeons and patients to radiation. In addition, Cakir et al. [11] reported that magnets could not be used to remove foreign bodies that were less than 0.5 cm long or those that were deeply embedded in the body. The failure to remove metallic foreign bodies can pose a psychological burden on patients and may cause painful local swelling, infection, functional disturbance, inflammatory granuloma formation, and blood vessel and nerve compression [1]. Heavy metal foreign bodies can also cause toxicity [12,13], and must be removed as soon as possible.

While the diagnosis of metallic soft-tissue foreign bodies is not difficult [14,15], surgery to remove metallic foreign bodies is often unsuccessful. One-third of all patients with soft-tissue foreign bodies who visit the Children's hospital of Chongqing Medical University have a history of failure of surgical treatment at their local hospital because the foreign body could not be found during surgery. Tiny foreign bodies are difficult to locate, even under direct vision. In such cases, the operation is usually prolonged, which increases the risk of iatrogenic injury. Furthermore, muscle contractions can cause retained thin, sharp, foreign bodies to travel throughout the body, causing local pain and functional limitations, such as limited limb movement, in mild cases and blood vessel and nerve injuries, and joint dysfunction in severe cases.

We hypothesized that the use of methylene blue to stain the tissue in which the foreign body is located would facilitate the identification of the tissue during surgery and thus help in the removal of foreign bodies. The purpose of this study was to determine the usefulness of this methylene blue staining technique in the surgical removal of tiny metallic foreign bodies embedded in the soft tissue in a cohort of pediatric patients.

2. Patients and methods

2.1. Patient selection

This prospective descriptive study was conducted between May 2007 and May 2012 in Orthopedics Department II of the Children's Hospital of Chongqing Medical University. The ethics committee of the hospital approved the study. The study methods were explained to and written informed consent was obtained from the parents or guardians of all the patients. In total, we enrolled 41 children with accidental embedment of tiny foreign bodies in the soft tissue. We excluded patients with foreign bodies that were >15.0 mm long or >3.0 mm wide. The patients were randomized to a methylene blue (experimental) group or a control group, using a computer-generated random number list.

2.2. Surgical procedures

All patients were treated by the same surgeon and his assistants. The surgeon had >15 years of experience in pediatric orthopedic surgery, and had performed more than 50 foreign-body removal surgeries.

In the control group, surgery was performed under general anesthesia. If a tourniquet was required to stem the flow of blood, it was inflated to 150–180 mm Hg. The object was located using C-arm fluoroscopy according to a preoperative X-ray examination, and its position was indicated by making a mark on the skin. The skin and subcutaneous tissues were incised vertically long the mark. The dissection was continued into the deeper layers until the metallic foreign body was visualized.

In the methylene blue group, the surgery was performed under general anesthesia. If a tourniquet was required to stem the flow of blood, it was inflated to 150–180 mm Hg. The foreign body was located using C-arm fluoroscopy according to the findings of a preoperative X-ray examination (Fig. 1a, b, and 2). A #7 needle tip was used to vertically puncture the skin where the foreign body was located (a waist puncture needle was used for foreign bodies embedded deeply). The C-arm was then rotated 90°, and the needle depth was adjusted to align the tip of the needle with the foreign body. Then, 0.2–0.3 ml methylene blue was injected, and the needle was removed. An incision was made in the skin and subcutaneous tissues at the most shallow point over the foreign body to locate the spot marked with methylene blue and find the foreign body.

2.3. Postoperative procedures

The foreign body–clearance rate was determined in both study groups. After the foreign bodies were removed, their lengths and diameters were measured. The incision length, operation time (from anesthesia induction to the end of the surgery), and the frequency of the use of C-arm irradiation were also recorded. Any bleeding during surgery and any postoperative complications, such as incision infection, were recorded. All the patients got the tetanus vaccination within 24 h after surgery and the antibiotic prophylaxis was used preoperatively and postoperatively in case of the infection by the foreign bodies. All patients were followed up for 6–12 months (average, 9 months) via telephone interviews or outpatient visits.

2.4. Statistical analyses

All measured data were expressed as means ± SD. SPSS 10.0 (IBM, Chicago, IL, USA) was used for the statistical analyses. The *t*-test was used for between-group comparisons, and differences were considered statistically significant at $P < 0.05$.

3. Results

3.1. General information

The methylene blue group (M group)consisted of 9 boys and 6 girls, ranging in age from 5 months to 10 years (average, 5.1 years). The control group(C group) comprised 16 boys and 10 girls, ranging in age from 7 months to 8 years (average, 4.8 years). The foreign bodies in the methylene blue group consisted of fractured sewing needles (10 patients) and iron nails and iron chippings (5 patients). In the control group, the foreign bodies consisted of intact and fractured sewing needles (18 patients), iron nails, and irregular iron fragments and iron chippings (6 patients), and medical syringe needles (2 patients). The foreign bodies were located in the hands in 5 patients(2 in M group, 3 in C group), in the forearm in 8 patients(2 in M group and 6 in C group), in the buttocks in 14 patients(5 in M group and 9 in C group), and in the lower extremities in 14 patients(6 in M group and 8 in C group). No significant difference was found between these groups ($p > 0.05$). The interval between foreign body embedment and presentation at our hospital ranged from 7 h to 15 d (average, 38 h). Eight patients in the methylene blue group and six patients in the control group had previously undergone surgery at their local hospitals; however, these surgeries had failed, and the patients were transferred to our hospital. No obvious complications occurred in either group during the entire follow-up period. The whole follow-up duration was 1 months, and there is no significant difference between these groups.

3.2. Size of foreign bodies

The length and diameter of the foreign bodies ranged from 5.0 to