“One-Stop Hybrid Procedure” in the Treatment of Vascular Injury of Lower Extremity

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Abstract As a new surgical technique, “one-stop hybrid procedure” is rarely applied in trauma patients. This paper aims to explore its role in vascular injury of the lower extremity. Vascular intervention combined with open surgery was performed to treat three cases of vessel injuries of the lower extremity in our hybrid operating room. One patient with stab injury to the left femoral vein was treated by temporary artery blocking after excluding arterial injury by angiography, followed by blocking surgery and debridement and repair of the injured vein. The other two patients with drug addiction history, who were found to have pricking injuries to the femoral artery combined with local infection, were successfully treated by endovascular techniques and open debridement. One-stop hybrid procedure in treating vascular injury patients could simplify the operation procedure, reduce operative risk, and achieve good curative effect.

Keywords Vascular injury · Trauma · Treatment · One-stop hybrid procedure

Introduction

Endovascular technology is becoming widely accepted as a mini-invasive method for treating vascular disease. Since Angelini et al. [1] initially reported a new mini-invasive approach named “hybrid procedure” in 1996, i.e., combining left

anterior small thoracotomy and percutaneous transluminal coronary angioplasty, this hybrid procedure has been commonly applied in patients with heart disease and has often been used as a staging treatment strategy or postoperative intervention. Thanks to the development of imaging and endovascular technology, “one-stop hybrid procedure” can be carried out in a hybrid operating room, which provides a good platform for many new-type micro-invasive surgical approaches. The vascular interventional technique demonstrates a distinctive advantage for treatment of vascular injury. Karkos et al. [2] reported a hybrid procedure using both open and endovascular techniques to treat subclavian artery injuries. In this study, we firstly applied one-stop hybrid surgical procedure for the management of lower extremity vascular injury.

One-Stop Hybrid Operating Room

The one-stop hybrid operating room is equipped with digital subtraction system (Innova 3100-IQ, GE Healthcare, USA), high-pressure syringe (Acist angiographic injection system, Bracco Company, Italy), ECG monitor, defibrillator, anesthesia machine (7800A, Yi'an, Beijing, China), surgical lights (LssL-2206, Chongqing Tianhai Medical Equipment Co., Ltd., Chongqing, China), and Class 100 laminar flow clean bench (Siyuan Building Company, Chongqing, China).

Case Reports

Case Report 1

A 41-year-old woman was admitted to our hospital 2 h after bleeding resulting from a stab wound to the left side of the groin. Physical examination on admission indicated body temperature 37.0 °C, heart rate 87 beats/min, respiratory rate 20 breaths/min, and blood pressure 120/71 mmHg. A stab

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wound of about 3 cm in length was observed inside the left groin with active bleeding (dark red blood) but with normal pulsation in the femoral artery, popliteal artery, and dorsalis pedis artery. Blood test indicated Hgb 89 g/L, Hct 26.0 %, WBC $12.20 \times 10^9/\text{L}$, and CRP $<1 \text{ mg/L}$. She underwent emergency operation in the one-stop hybrid operating room. Femoral arteriography via the right femoral artery demonstrated no arterial injury. Temporary proximal occlusion of the femoral artery was accomplished with a balloon catheter, followed by local wound debridement and femoral vein repair. She was discharged 9 days after operation (Fig. 1).

Case Report 2

A 27-year-old man with history of drug addiction was admitted to our hospital due to local bleeding and swelling 2 months after repeated injections to the right groin. Physical examination indicated body temperature 36.9°C , heart rate 85 beats/min, respiratory rate 19 breaths/min, and blood pressure 118/78 mmHg. There was a $10 \text{ cm} \times 8 \text{ cm} \times 5 \text{ cm}$ mass in the right groin with a $5 \text{ cm} \times 5 \text{ cm}$ bleeding ulcer combined with swelling, warmth, and palpable femoral artery, popliteal artery, and dorsalis pedis artery. Blood examination indicated Hgb 77 g/L, Hct 23.0 %, WBC $15.07 \times 10^9/\text{L}$, and CRP 189 mg/L. Based on the results of injury re-assessment after admission and 64-slice spiral computed tomography angiography (CTA) examination, he was diagnosed as having right femoral artery pseudoaneurysm combined with infectious hematoma. Finally, he underwent operation in the one-stop hybrid operating room. Fortunately, there was no sign of infection in the left groin area. Catheters were placed in the left femoral artery to achieve temporary occlusion of the right femoral artery. After complete occlusion as confirmed by angiography, local wound debridement and femoral artery ligation were performed progressively. During the operation, methylene blue was injected into the femoral artery through a balloon catheter to benefit exposure and ligation. The patient was discharged 12 days after operation and had good recovery at 4-month follow-up (Fig. 2).

Case Report 3

A 29-year-old man with history of drug addiction was admitted to our hospital with 4 days history of bleeding and swelling following left groin injection. Physical examination indicated body temperature 37.2°C , heart rate 123 beats/min, respiratory rate 23 breaths/min, and blood pressure 131/79 mmHg. He had a mass of 6-cm diameter with 3-cm central ulceration combined with swelling, warmth, and weak pulsation of the femoral artery, popliteal artery, and dorsalis pedis artery. Blood examinations indicated Hgb 79 g/L, Hct 25.4 %, WBC $10.9 \times 10^9/\text{L}$, and CRP 27 mg/L. After re-assessment and 64-slice spiral CTA examination, he was also diagnosed as having left femoral artery pseudoaneurysm and infectious hematoma. Finally, he underwent operation in the one-stop hybrid operating room. A catheter was placed in the left femoral artery via a puncture in the right artery, where there was no evidence of infection, to perform embolization of the left femoral pseudoaneurysm with steel coil and gelatin sponge particles. After complete occlusion of the bleeding site as confirmed by angiography, local wound debridement was carried out. The patient was transferred to the local hospital 1 day after operation. He had good recovery at 1-month follow-up (Fig. 3).

Discussion

Endovascular intervention is an important technique for vascular surgery, which is also considered mini-invasive. As endovascular interventional technique is proved to be effective in the clinic as a valuable complement to traditional surgery, the concept of “hybrid operation” comes into being. Early hybrid procedure could not provide one-stop service, which is the combined use of staging coronary stent implantation and bypass surgery for the treatment of coronary heart disease [1]. The one-stop hybrid operating room is equipped with imaging instruments, so imaging examination and routine surgery can be simultaneously performed, avoiding transferring patients between the intervention room and the

Fig. 1 Left groin stab angiography showed normal visualization of the external iliac artery, femoral artery, and their branches (a); after performing temporary balloon occlusion of the proximal femoral artery, the proximal and distal ends of the injured femoral vein were

exposed, blood flow was blocked with vascular forceps, and vessel repair was conducted with 5–0 Prolene sutures (b); after surgical repair, hydrogen peroxide and saline were used to repeatedly wash the trauma site, observing fresh wounds and good repair (c)

Fig. 2 A 10 cm×8 cm×5 cm infectious hematoma was observed, which was caused by injection injury to the right groin (a); angiography showed femoral artery pseudoaneurysm formation (b); after carrying out proximal temporary balloon occlusion of the femoral artery,

local debridement was performed. With the help of methylene blue injection, the proximal and distal ends of the femoral artery were dissected and ligated, and the surgery site was washed repeatedly with hydrogen peroxide and saline (c)

operating room and reducing the risks caused by repeated anesthesia and transport. One-stop hybrid operation procedure has the following characteristics: (1) surgery can be performed in the same operating room with multiple imaging equipment, (2) surgeons can complete the operation using the intervention equipment, and (3) surgeons can highly rely on imaging guidance for surgical procedures and provide an immediate evaluation for surgical treatment [3, 4].

The combined use of traditional surgery and intervention had been widely used in trauma patients in the 1990s, such as hepatic arterial embolization for severe liver injury and internal iliac artery embolization for pelvic fracture [5, 6]. However, these techniques were often used for severe patients who cannot tolerate operation or patients with post-operative bleeding. It is believed that the one-stop hybrid operation procedure proposed by cardiac surgeons has great potential in severe trauma treatment. This technique allows surgeons to perform hybrid operation in the same anatomical site in the hybrid operating room, which is consistent with the “damage control” principle. It can also change the traumatic treatment mode from the “combination” to the “integration” mode. With this technique, surgeons can do operation immediately after vascular intervention or perform intervention during operation. This technique with

the above advantages has no doubt to build a new platform for trauma care and helps to increase the timeliness and security of trauma treatment.

This paper reports three cases of vascular injury, which is, to our knowledge, the first report of a hybrid procedure for lower extremity vascular injury patients. The treatment for the first case is emergency trauma management, and the treatment for the other two cases is trauma complications management. For case 1, vascular intervention is used to perform angiography with local wound dressing pressing to confirm whether there is arterial injury, and temporary artery occlusion can help reduce venous bleeding. For patients with drug addiction or femoral artery injury combined with pseudoaneurysm rupture and local wound infection, e.g., case 2 and case 3, vascular intervention can avoid the temporary occlusion of the external iliac blood vessels in the traditional extraperitoneal approach or abdominal approach, reduce the trauma and its potential risk of infection, and reduce the risk of local anatomy or femoral vein injury managed by surgical treatment. We realize that temporary blocking using a balloon catheter or blocking using vascular intervention materials such as metal coil and PVC is effective for control of acute vascular injury or pseudoaneurysm rupture, greatly facilitating the removal of hematoma and wound debridement during the operation.

Fig. 3 Angiography showed femoral artery pseudoaneurysm formation (a) and successful embolization at the proximal and distal ends of the femoral artery with steel coil and gelatin sponge particles (b); the

patient had a mass of 6-cm diameter with 3-cm central ulceration (c); the foci after local debridement (d)

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