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Hybrid treatment combining emergency surgery and intraoperative interventional radiology for severe trauma

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ABSTRACT

Object: To evaluate the efficacy of hybrid treatment combining emergency surgery and intraoperative interventional radiology (IVR) for severe trauma.
Patients and methods: The records of 63 severely injured patients who underwent concurrent emergency surgery and IVR at our emergency centre from 1999 through 2013 were retrospectively reviewed. Mobile digital subtraction angiography device was used in the operating room when performing IVR. Patients undergoing hybrid treatment combining intraoperative IVR and emergency surgery (intraoperative IVR group) were compared with those undergoing IVR in the angiography suite before or after emergency surgery (control group).
Results: Thirteen patients underwent hybrid treatment (intraoperative IVR group). Of these 13 patients, 7 underwent treatment for abdominal organ injuries, and 6 for multiregional injuries. Emergency operations were laparotomy ($n = 12$), thoracotomy ($n = 1$), craniotomy ($n = 1$), and haemostasis of the lower extremities ($n = 1$). Five patients underwent damage control surgery. IVR included transarterial embolisation ($n = 12$), endovascular stent or stent-graft placement ($n = 2$), and embolisation of a portal vein by laparotomy ($n = 2$). The mean ISS was 40. The actual overall survival rate was 85%, and the probability of survival (Ps) was 62%. The control group included 45 patients. Five patients who met exclusion criteria were not included in the control group. Age, ISS, RTS, Ps, pH and base excess on arrival, and blood transfusion volume during operation and IVR did not differ significantly between the groups. Total time during operation and IVR was significantly shorter in the intraoperative IVR group than in the control group (229 [SD 72] min vs. 355 [SD 169] min; $p = 0.007$). The mortality were 15 (95% CI 2–45) % in the intraoperative IVR group vs. 36 (95% CI 22–51) % in the control group.
Conclusion: Hybrid treatment combining emergency surgery and intraoperative IVR can be a novel treatment strategy for severe trauma, and it will improve patient outcomes due to reduction of the time for resuscitation.

Introduction

Identifying ongoing haemorrhage and achieving haemostasis as rapidly as possible are central to improving outcomes in severely injured patients. Interventional radiology (IVR) can play a unique diagnostic and therapeutic role in the management of acute major trauma, because it allows a more rapid and less invasive procedure when compared with surgery in the control of haemorrhage [1–3]. IVR techniques used to control bleeding include embolisation to occlude arteries or veins, stenting or stent grafting to repair injured vessels, and temporary balloon arterial occlusion. Transarterial embolisation (TAE) is currently well established as an effective means of dealing with arterial haemorrhage in trauma patients, and endovascular techniques for treatment of vascular injury have proven to be effective as an alternative to open surgical repair [1–3]. IVR and surgery are complementary interventions for severe trauma, and IVR contributes to damage control principles by

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controlling haemorrhage when definitive repair is impossible [2,3]. The effectiveness of TAE to control arterial haemorrhage after damage control surgery in haemodynamically unstable patients has been reported [4–8].

In severely injured patients, the time of resuscitation and treatment should be as short as possible. Therefore, hybrid treatment combining emergency surgery and IVR in the operating room is an ideal treatment strategy. However, this new treatment strategy for severe trauma has not been widely described in the literature.

In this clinical study, the efficacy of intraoperative IVR with a mobile digital subtraction angiography (DSA) device in combination with emergency surgery for patients with severe trauma was evaluated.

Patients and methods

The records of 63 severely injured patients who underwent both emergency surgery and IVR concurrently over a 14-year period from 1999 through 2013 were retrospectively reviewed. Two thousand severely injured patients (ISS [9] >15) except patients of cardiopulmonary arrest on arrival underwent treatment at our emergency centre over this 14-year interval, of whom 96% were blunt trauma patients. Four hundred forty patients underwent emergency surgery except orthopaedic surgery, three hundred forty patients underwent emergency IVR. Patient data were obtained from the hospital's trauma registry and medical records. All study protocols were approved by the institutional review board.

Data examined included age and sex, ISS, revised trauma score (RTS) [10,11], probability of survival (Ps) [12], pH and base excess (arterial blood gases on arrival), blood transfusion volume during emergency surgery and IVR, total time during emergency surgery and IVR, and the overall in-hospital mortality rate. The ISS was calculated according to the Abbreviated Injury Scale 90 Update 98 [13], and the Ps was calculated using TRISS methods [12]. The transfused blood volume was the total volume of red blood cells and fresh-frozen plasma. Total time during emergency surgery and IVR was calculated from the start of the operation or IVR to the finish of the operation or IVR.

Trauma patients were treated according to the Advanced Trauma Life Support protocol. During the primary survey, all patients underwent ultrasonography to look for fluids in the pericardial, thoracic, and peritoneal cavities, and underwent plain chest and pelvic X-rays in the emergency room. CT scanning was performed in patients who were haemodynamically stable with or without fluid resuscitation.

All patients who were selected for hybrid treatment were transferred directly to the OR. In the situation that we could not perform hybrid treatment, haemodynamically unstable patients who did not respond to fluid resuscitation were transferred directly to the OR before the angiography suite, and patients who recovered from shock with fluid resuscitation were transferred to the angiography suite before the OR.

The indications for hybrid treatment combining emergency surgery and intraoperative IVR were as follows: (1) severe injury in which combined treatments of damage control surgery and IVR are effective, e.g., severe hepatic injury; and (2) multiple injuries including both injury requiring an emergency surgery and injury requiring IVR, e.g., diaphragmatic injury and unstable pelvic fracture, gastrointestinal perforation and splenic injury. (1) and (2) are under haemodynamically unstable conditions. Because of staffing considerations, hybrid treatment combining emergency surgery and intraoperative IVR could be performed in the operating room only during the daytime and on weekdays.

IVR included transarterial embolisation by percutaneous vascular access, endovascular stent or stent-graft placement for an artery or vein, embolisation of a portal vein by laparotomy, and temporary balloon occlusion for an artery. Gelatine sponge strip, steel coils, or NBCA (n-butyl-2-cyanoacrylate) was used as a haemostatic embolisation agent.

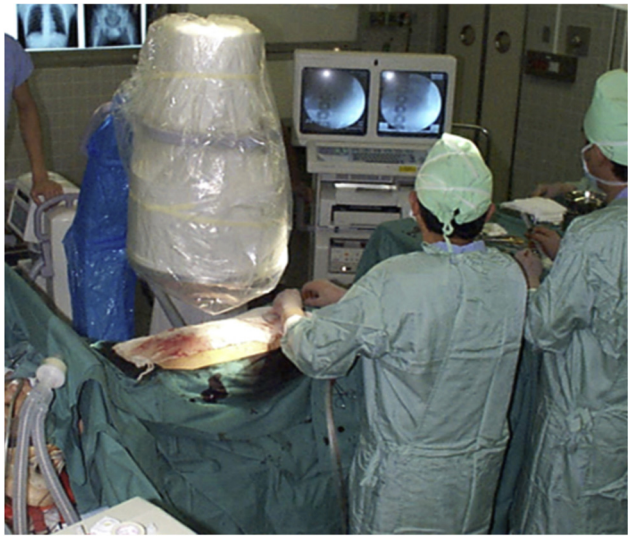
The indication for angioembolisation was extravasation of contrast medium from abdominal organs or the retroperitoneum on the torso CT scan. A finding of major vessel injury on CT scan and/or angiography was the indication for stent or stent-graft placement. In haemodynamically unstable patients, detection of pericardial, peritoneal, or thoracic fluid on ultrasonography, and/or a finding of an unstable pelvic fracture on pelvic X-ray were the indications for emergency surgery. Emergency surgery included damage control surgery, which was gauze packing, ligation, or temporary closure. The indication for IVR in a haemodynamically unstable patient without a CT scan was decided based on intraoperative findings.

The decision to perform hybrid treatment combining emergency surgery and intraoperative IVR was made at the discretion of the attending acute care surgeon. An interventional radiologist was called as soon as the acute care surgeon made the decision to proceed with intraoperative IVR. The mean IVR response times from the time of the phone call to the time the IVR doctor arrived were from 20 to 30 min at night and on holidays. During the daytime and on weekdays, the IVR response time was within 10 min, because the IVR doctor was in the hospital. Acute care surgeons did not perform IVR treatments, but when patients were haemodynamically unstable, surgeons started arterial access for arterial pressure monitoring or balloon occlusion in the emergency room.

A mobile DSA device with a C-Arm image intensifier (Series 9800 Digital Mobile Imaging System; GE OEC Medical Systems, Tokyo, Japan) was used (Picture 1). The IVR procedures were performed by the interventional radiologist of our emergency centre. The mobile DSA device was operated by the radiological engineer.

Comparisons were made between patients who underwent intraoperative IVR in combination with emergency surgery (intraoperative IVR group) and those who underwent IVR in the angiography suite before or after emergency surgery (control group). Exclusion criteria included patients 15 years old or younger, patients who were admitted to the intensive care unit between the operation and IVR, and patients who underwent only emergency surgery for extremity fractures.

Categorical data were analysed with a Fisher's exact test. Continuous data were analysed with a Mann–Whitney test.



Picture 1. IVR using a mobile C-Arm DSA without peritoneal closure in OR.