

# Hybrid emergency room management of a ruptured abdominal aortic aneurysm

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## ABSTRACT

Patients with a ruptured abdominal aortic aneurysm (rAAA) still have high mortality. Rapid diagnosis and treatment are vital for improving survival outcomes. rAAA management has evolved regarding these factors. We have reported the case of a 70-year-old man with an rAAA that was rapidly diagnosed and treated in a hybrid emergency room (ER). A hybrid ER is an integrated ER capable of computed tomography scanning, interventional radiology, and surgery in one place. In the present case, the door-to-intervention time was 35 minutes. The use of hybrid ERs has the potential to enhance the speed and quality of diagnostic and definitive treatment of rAAAs. (*J Vasc Surg Cases and Innovative Techniques* 2021;7:21-5.)

**Keywords:** Endovascular aneurysm repair; Hybrid emergency room; Ruptured abdominal aortic aneurysm

Patients with a ruptured abdominal aortic aneurysm (rAAA) have high morbidity and mortality rates.<sup>1-4</sup> rAAAs require early diagnosis, control of significant hemorrhage, and a multidisciplinary approach involving emergency services, radiology, and an operating room (OR). The multiple transfers required from the emergency room (ER) to radiology for computed tomography (CT) scanning and then to OR for treatment are highly time-consuming. Management to reduce the time from presentation to definitive care will improve the survival outcomes.<sup>5</sup>

The use of hybrid ERs has been increasing in Japan. This system is an integrated ER with the capabilities for CT scanning, interventional radiology, and surgery. The use of a hybrid ER is desirable for trauma care because these patients can undergo CT scanning, hemorrhage control using IR, and surgery in one room (Fig 1, A).<sup>6</sup> The use of a hybrid ER enables rapid diagnosis and hemorrhage control because the time-consuming transfers are avoided. We believe this novel system will be extremely useful in treating rAAAs. We have presented a patient with a life-threatening rAAA that was rapidly treated from diagnosis to definitive care in a hybrid ER. The patient provided written informed consent to report his case.

## CASE REPORT

A 70-year-old man was transported to the hybrid ER because of acute-onset low back pain and hypotension. The hybrid ER was selected because his symptoms indicated an emergency. On arrival, he was significantly distressed (Fig 1, B), with a blood pressure of 85/59 mm Hg, heart rate of 91 beats/min, respiratory rate of 26 breaths/min, and temperature of 36.0°C. The abdominal examination revealed a distended abdomen with severe tenderness. Fluid resuscitation was initiated, and he underwent contrast-enhanced CT on the same bed (Fig 1, C). The CT scan revealed an 84-mm infrarenal AAA with a massive retroperitoneal hematoma and a 47-mm proximal neck of sufficient length for repair. A 33-mm aneurysm involving the right common iliac artery with no distal neck was also present, and the right external iliac artery had an adequate healthy landing zone (Fig 2, A-C). The time from the initial clinical presentation to radiographic diagnosis was 25 minutes (Table).

After the rAAA was diagnosed, treatment was immediately initiated with the patient under general anesthesia on the same bed. Initially, endovascular balloon occlusion (EBO) was performed under fluoroscopic guidance for proximal aortic control. The aortoiliac anatomy was suitable for minimally invasive emergency endovascular aneurysm repair (EVAR). His vital signs had quickly stabilized with EBO. EVAR was, thus, performed with a surgical femoral cutdown. Right internal iliac artery embolization was performed before EVAR to achieve a suitable right external iliac artery landing zone. This was performed in the hybrid ER at 60 minutes after the patient's presentation (Fig 3, A). Initially, the right internal iliac artery was embolized with an 8-mm AMPLAZER Vascular Plug IV (St. Jude Medical, St. Paul, Minn). Subsequently, an aortobilateral stent-graft (GORE C3 Delivery System; WL Gore & Associates, Flagstaff, Ariz) was deployed just below the renal arteries to cover the aneurysm through the bilateral common femoral artery. Satisfactory deployment of the stent-graft was confirmed with intraoperative completion angiography (Fig 3, B). The duration of EVAR was 106 minutes. His vital signs had quickly stabilized without EBO, although abdominal distension was prominent, with respiratory concerns such as a

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Author conflict of interest: none.

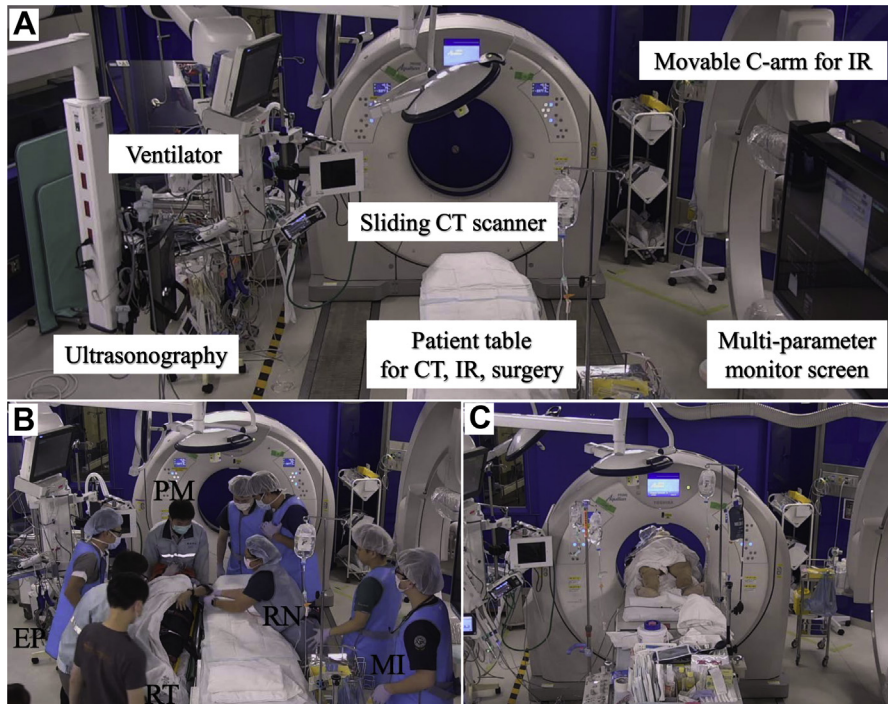
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The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2468-4287

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<https://doi.org/10.1016/j.jvscit.2020.12.006>



**Fig 1.** Hybrid emergency room (ER) system. **A**, The hybrid ER system is an all-in-one system that includes a surgery table, computed tomography (CT) scanner, ultrasonography device, ventilator, and fluoroscopy equipment for interventional radiology (IR). Critically ill patients can undergo all life-saving procedures on the same table without transfer. **B**, On arrival, resuscitation was initiated. **C**, The patient underwent contrast-enhanced CT on the same table. EP, Emergency physician; MI, medical intern; PM, paramedic; RN, registered nurse; RT, radiology technician.

high peak airway pressure. The intra-abdominal pressure was 36 mm Hg, and decompressive laparotomy was performed for abdominal compartment syndrome in the same room at 199 minutes after presentation (Fig 4, A). The intra-abdominal pressure decreased to 10 mmHg, and his respiratory status improved significantly (Fig 4, B). Vacuum-assisted closure was performed for temporary abdominal closure, and he was admitted to the intensive care unit.

He returned to the usual OR 32 hours later for definitive abdominal wall closure. He was extubated on postoperative day 7. His postoperative course was uneventful, and CT scans showed no endoleak. He required rehabilitation because of intensive care unit-acquired weakness but was discharged asymptomatic on postoperative day 70.

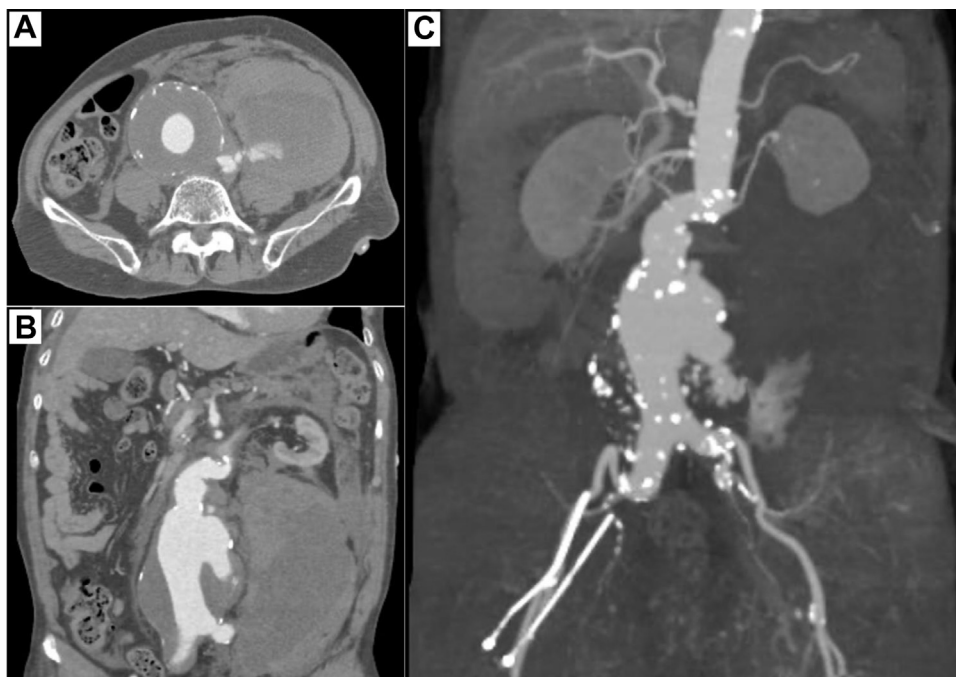
## DISCUSSION

EVAR has replaced open surgical repair (OSR) as standard therapy for AAA, even in the setting of rupture.<sup>7-10</sup> Rapid hemorrhage detection and control clearly improve survival in conditions with massive hemorrhage. Innovative medical technology is needed to shorten the time from arrival to hemorrhage detection and control. CT scans and transferring patients to an angiography suite or the OR are significantly time-consuming. A

hybrid ER, which allows for CT imaging, endovascular intervention, and surgery, offers various possibilities for treating hemorrhagic shock. We treated this patient with rAAA in shock within a short period from diagnosis to definitive care using our hybrid ER.

Regarding trauma care, several studies have reported that hybrid ER use was significantly associated with a decreased time to diagnosis, improved definitive treatment, and reduced mortality.<sup>11-13</sup> The hybrid ER can also be used for nontrauma patients requiring CT, angiography, and surgical procedures. From the perspective of life-threatening hemorrhagic shock, a rAAA results in effects similar to those with trauma. Therefore, rAAA could be one of the most effectively treated diseases in hybrid ERs.

Several major guidelines have recommended EVAR as first-line therapy and a “door-to-intervention” time of  $\leq 90$  minutes in a ruptured setting.<sup>14,15</sup> EVAR is less invasive; however, preoperative anatomic evaluation using imaging studies is required to determine its feasibility. Decision-making should be quick and determined by individual and institutional circumstances. However, resuscitation and multiple transfers for diagnosis and surgery are time-consuming. A recent national clinical registry study in the United States showed that only 53.5% of patients who had



**Fig 2.** Computed tomography (CT) images revealed an 84-mm infrarenal ruptured abdominal aortic aneurysm (rAAA) with a massive retroperitoneal hematoma with a severity of type 4 per Fitzgerald's classification. **A**, Axial view. **B**, Coronal view. **C**, Three-dimensional reconstruction of the CT scan.

**Table.** Time to critical events from presentation in hybrid ER

Time, minutes	Event	Blood pressure, mm Hg	Heart rate, bpm	Additional notes
0	Presentation	85/59	91	
20	CT scan	79/60	95	Vasopressor started
25	rAAA diagnosed	60/45	105	Intubated; massive blood transfusion
35	EBO inflated	150/83	100	
60	EVAR started	120/70	93	IIA embolization
103	EBO deflated	110/65	100	Stent-graft placed
166	EVAR completion			
	Decision for laparotomy			IAP 36 mm Hg
199	Laparotomy started	120/70	100	
239	NPWT device placed	180/86	95	IAP 10 mm Hg
250	Transfer to ICU	150/70	90	Hemodynamically stable without a vasopressor

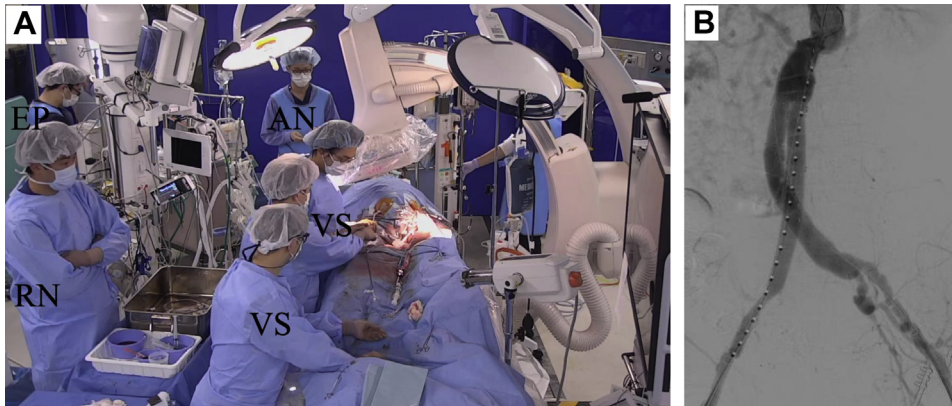
CT, Computed tomography; EBO, endovascular balloon occlusion; ER, emergency room; EVAR, endovascular aneurysm repair; IAP, intra-abdominal pressure; ICU, intensive care unit; IIA, internal iliac artery; NPWT, negative pressure wound therapy; rAAA, ruptured abdominal aortic aneurysm.

undergone emergency EVAR for rAAAs had had a door-to-intervention time of  $\leq 90$  minutes.<sup>16</sup> The use of hybrid ERs could drastically reduce the door-to-intervention time.

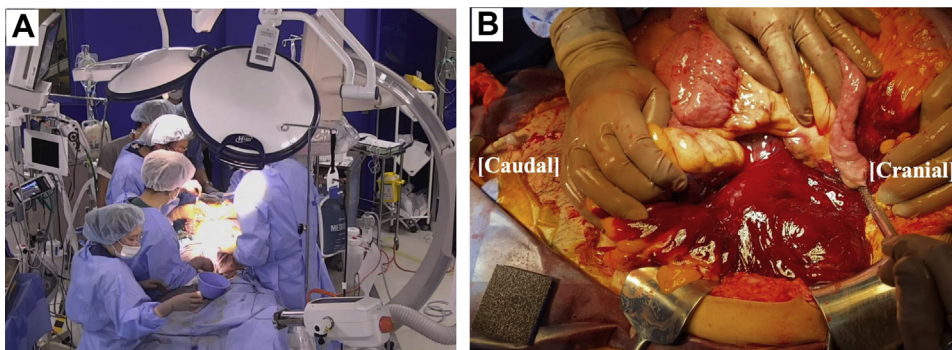
However, the use of hybrid ERs is too resource intensive and time-sensitive for all emergencies. Diagnosing rAAAs in a prehospital setting is difficult. At our hospital, the hybrid ER is used for patients with hypovolemic shock signs noted using prehospital medical information. Our hospital treats ~1000 patients annually in the hybrid ER, ~5% of all emergency visits. The most common diagnoses treated in the

hybrid ER were cardiac arrest (40%), trauma (35%), and other endogenous diseases (25%). Further studies are needed to evaluate the benefits and optimal selection criteria for hybrid ER usage.

OSR for rAAA is also available in our hybrid ER. However, use of the hybrid ER should be saved for critically ill patients. Therefore, if patients with rAAAs have permissively hemodynamic instability, definitive surgical hemostasis would be performed in a standard OR, regardless of whether EVAR or OSR were performed.



**Fig 3.** **A**, Endovascular aneurysm repair (EVAR) for ruptured abdominal aortic aneurysm (rAAA) in the hybrid emergency room (ER). **B**, Intraoperative angiogram demonstrating exclusion of the aneurysm and no endoleak. AN, Anesthesiologist; EP, emergency physician; VS, vascular surgeon.



**Fig 4.** Laparotomy in the hybrid emergency room (ER). **A**, Decompressive laparotomy for abdominal compartment syndrome. **B**, Intraoperative findings showing a large hematoma in the left retroperitoneal region.

The time of diagnosis from hospital presentation using the hybrid ER is very short; therefore, a delay remains until the vascular surgeons arrive. An established protocol with a “hybrid multidisciplinary team” involving vascular surgeons, anesthesiologists, and emergency physicians is thus essential for managing rAAAs. Ideally, each specialist would remain in the hospital for 24 hours every day; however, human resources are limited. Our hospital has been certified by the regional administration affairs as a level 1 trauma center. Local government policy mandates an in-house acute care surgeon, and each specialist, including vascular surgeons, should be able to reach the ER within 30 minutes of presentation. Thus, the patient underwent immediate surgery. The door-to-intervention time was 35 minutes. However, most hospitals lack a rapid response system to call for vascular or in-house surgeons. Regionalization of acute aortic syndromes can make efficient use of hybrid ERs and might improve outcomes.<sup>17</sup>

## CONCLUSION

The use of a hybrid ER allows for a rapid, accurate diagnosis and definitive treatment of rAAAs. Although it is a revolutionary modality, establishing a system for managing

rAAAs using a hybrid ER is essential for optimal outcomes. Further study is needed to prove the clinical effectiveness and efficiency of hybrid ERs.

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Submitted Sep 7, 2020; accepted Dec 15, 2020.