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CLINICAL REPORT

Application of positive end-expiratory pressure in a case with large laceration on the superior vena cava

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Abstract Iatrogenic injury is a difficult situation for a surgeon. Being successful in saving a patient at risk is the major concern in this situation. Once an iatrogenic injury to the superior vena cava (SVC) is found, increasing the intrathoracic pressure is theoretically able to overcome the venous pressure and to alleviate or even stop bleeding from injury. A 76-year-old female patient, who had suffered from end-stage diabetic nephropathy, developed tension hemothorax during insertion of the cuffed hemodialysis catheter. The successful course of resuscitation without emergent operation or endovascular repair is presented here.

Keywords PEEP · Hemothorax · Iatrogenic SVC injury

Introduction

Iatrogenic hemothorax is a dreadful experience for medical staff that sometimes occurs. It could possibly be caused by malpractice of transvenous procedures, such as central venous catheterization, pacemaker implantation, and dialysis catheter insertion. When the injury is caused by a puncture needle with a small caliber or a dilator, most hemothoraces, with a limited amount of blood, are managed with conservative treatment with or without chest tube drainage. However, there are few reports discussing the management of injury to the superior vena cava (SVC) caused by a large-size inserting sheath. Emergent operation to check the bleeding, which would then lead to hypovolemic shock or hemothorax, always challenges the surgeons and anesthesia staff. A mortality rate of 40% has been reported in this catastrophic scenario [1]. We present an uremic patient who developed tension hemothorax and hypovolemic shock during the procedure of inserting the cuffed hemodialysis catheter and was successfully rescued without exploratory sternotomy or thoracotomy.

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Case report

A 76-year-old female patient, who had been suffering from end-stage diabetic nephropathy, was prepared for hemodialysis. She was blind because of cataract and glaucoma, yet her consciousness was clear. She had been bedridden for 3 years after fracture of the right femoral neck. She also had a history of hypertension and ischemic heart disease as well. On admission, she was chronically ill in appearance, with a body mass index (BMI) of 18.5 kg/m^2, blood pressure (BP) of 151/64 mmHg, and pulse rate (PR) of 80 beats per minute. Laboratory tests showed the following: blood urea nitrogen (BUN) 88 mg/dl, blood creatinine 9.6 mg/dl, creatinine clearance rate 2.9 ml/min, and positive antihepatitis C virus (anti-HCV) antibody. The daily protein loss was estimated to be 0.95 g/day. The radiologic examination of posteroanterior (PA) chest position showed cardiomegaly, atherosclerosis of the tortuous aorta, and the aortic arch being at the right side, which is different from that in most people. The ECG demonstrated a normal sinus

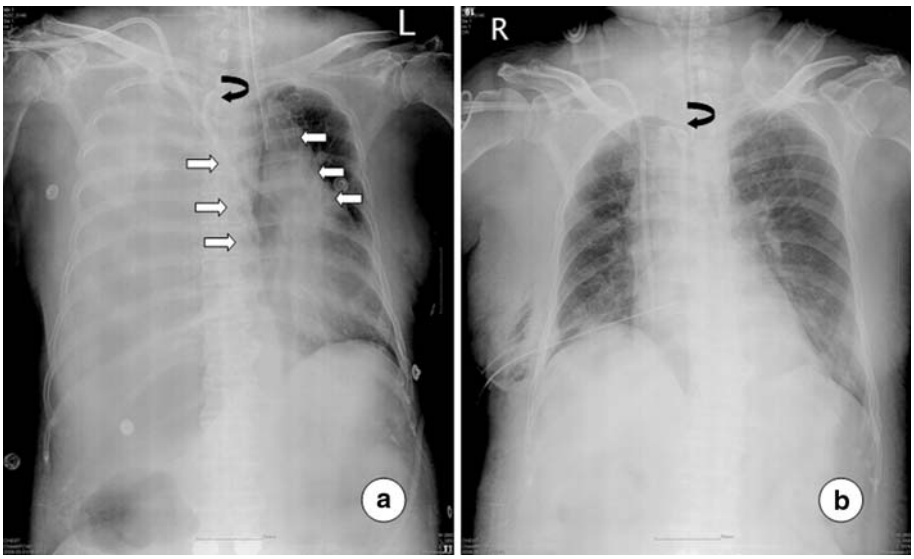

Fig. 1 **a** A shift to left of the mediastinum by tension hemothorax was indicated between the *white arrowheads*. An aortic arch on the right side showed atherosclerosis (*black spiral arrow*). **b** The mediastinum shifted back to normal position with the cuffed hemodialysis catheter in place

Table 1 Data of arterial blood gas analysis

	pH	$PaCO_2$ (mmHg)	PaO_2 (mmHg)	HCO_3 (mmol/l)	SaO_2 (mmol/l)	FiO_2 (%)	PEEP (cmH_2O)
First day	6.890	71.9	131.3	13.5	93.9	100	10
Second day	7.429	21.3	219.7	13.8	99.8	60	10
Third day	7.395	40.3	114.1	24.1	98.4	40	5

FiO_2 fraction of inspired oxygen, *PEEP* positive end-expiratory pressure

rhythm pattern with abnormal T-wave. There were no obvious superficial veins available to create an arteriovenous (A–V) shunt.

The insertion of the cuffed hemodialysis catheter (Quinton cuffed hemodialysis catheter; Dual Lumen Catheters, Kendall, Tyco International, Mansfield, MA, USA) was performed under local anesthesia. Direct puncture of internal jugular vein was done at the base of the right neck empirically. At first the guidewire was sent into the right heart under monitoring of the ECG. After the small dilator test, the Oval Pull-apart Introducer Sheath (13.5 Fr) was then inserted into the superior vena cava by the Seldinger technique. The patient then began to complain of sharp chest pain and immediately exhibited a cold sweat. Then her heartbeat began to slow and her BP dropped. Suddenly, the patient lost consciousness and an asystole was noted; the cuffed hemodialysis catheter had been indwelled during this meantime. Resuscitation was performed with endotracheal intubation and fluid challenge through the cuffed hemodialysis catheter route. Dopamine 10 μg/kg/min was also offered to increase BP. Emergent transthoracic echocardiography showed an insignificant pericardial effusion without signs of cardiac tamponade, but a massive hemothorax in the right pleural space was found. After fluid challenge and intravenous bolus of epinephrine 5 mg, a ventricular tachycardia developed, and cardioversion was then performed to achieve normal sinus rhythm. A sinus tachycardia (120 beat/min) was noted, and her BP suddenly increased to 190/110 mmHg and then decreased to 80/60 mmHg gradually.

The patient was sent to the intensive care unit and ventilated with positive end-expiratory pressure (PEEP) at 6 cmH_2O. Her blood pressure dropped to 60 mmHg again, and chest X-ray showed a tension hemothorax in the right pleural space (Fig. 1). Then, 1400 ml fresh blood was removed from right pleural cavity by inserting a chest tube, and 2000 ml blood with packed red cells and 4 U frozen fresh plasma were then transfused. A triple-lumen central vein catheter was inserted into the right femoral vein to monitor the central venous pressure (CVP) and fluid supply. Not only for this emergent setting, but also for her vital support, the patient relied only on the cuffed hemodialysis catheter for continuous venous–venous hemodialysis. After the PEEP was increased to 10 cmH_2O, the CVP in the femoral vein was 18 mmHg, the drainage amount decreased to less than 50 ml blood in the second hour, and the patient gradually became stable. Blood gas data are listed in Table 1.

After PEEP of 10 cm H_2O was applied for 48 h, the drainage amount further decreased to 100 ml per 24 h; PEEP was then returned to 5 cmH_2O. The chest tube was removed on the fifth day after the emergent procedure. The

cuffed hemodialysis catheter was removed on the 28th day because of wound infection. Another insertion of the cuffed hemodialysis catheter was performed on the same inserting site 2 weeks later. Tracheotomy was performed on the 48th day because of ventilator dependence. The patient was then transferred to a chronic care center on the 60th day with a clear consciousness.

Discussion

Fatal hemothorax following large-bore percutaneous cannulation is a rare but dreadful iatrogenic complication [2]. Urgent sternotomy for iatrogenic injury to the SVC is still an effective conventional method to rescue a collapsed patient [3]. Nevertheless, a patient with large laceration of the SVC, hypovolemic shock, and cardiac arrest may not be an adequate candidate for this procedure [4]. Endovascular repair seems a new helpful option for this type of injury, but the endovascular technique does not yet seem available in every hospital [5]. Venous bleeding can always be controlled with a simple suture technique or compression around the soft tissue of the puncture site in the extremities or neck, but it would be very dangerous when bleeding occurred from the SVC because it is located in the thoracic cavity with negative pressure. In the patient being intubated with an endotracheal tube, an SVC laceration could be compressed by the fully inflated lungs to stop bleeding with adequate PEEP support. A small puncture injury in the SVC, such as a puncture caused by a pacemaker electrode, could be successfully treated with PEEP [6]. PEEP does work well to rescue patients in danger from a large laceration wound in the SVC, although there were some reports stating that higher PEEP had no effect to stop bleeding during cardiac surgeries [7, 8]. Increases in PEEP are often associated with cardiovascular depression, responding to fluid loading. Significant hemodynamic compromise will be expected in hypovolemic shock if no adequate fluid supplement is available in a patient with high PEEP support [9].

We monitored the CVP through the right femoral vein instead of the internal jugular vein or subclavian vein. Several prospective clinical observations showed the peripheral venous pressure (PVP) correlated well with the CVP, in which the PVP is about 2 mmHg higher than the CVP [10–12]. The pulmonary alveolar pressure had overcome the SVC pressure in this case. The SVC pressure was estimated at 8–9 mmHg when the PEEP was applied at 10 cmH_2O. Once the iatrogenic injury to the SVC was found, we should, theoretically, increase the intrathoracic pressure to overcome the venous pressure to stop bleeding just as is done to reverse the pressure in the right atrium of a newborn to allow shunting blood stopped by the flap valve of the foramen ovale. For this reason, we supposed a relatively high-valued PEEP would help to stop bleeding in this case. Cardiac tamponade might be a sequela to the SVC rupture. Emergent transthoracic echocardiography is indicated when SVC injury occurs [13]. The chest drainage was performed when the patient was intubated with prompt PEEP support. If chest drainage was performed before the PEEP, a consequential bleeding would be expected.

In conclusion, the PEEP is a safe and feasible method to save the patient endangered by a large laceration in the SVC, and we would recommend that mandatory exploratory thoracotomy be scheduled later.

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