Case Report

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Surgical Techniques and Perioperative Intensive Care for Multiple Heart and Aorta Injuries by Crossbow Arrows (Clinical Case)

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ABSTRACT

A 53-year-old male was delivered to Almazov National Medical Research Centre from the local emergency hospital in a 36 hours after he shot himself in the chest by two crossbow arrows. We diagnosed a multiple penetrating injury of a chest. On initial examination the patient has a clear conscious, hemodynamics was stable without inotropic and vasopressor support. Based on chest multispiral computed tomography performed earlier in the city hospital, the multiple injuries of the heart chambers, namely 12 perforations in the heart and the aorta were confirmed. In this way it was considered to remove heart from pericardium and then close chambers' defects, perform mitral valve replacement and aortic valve repair with following autotransplantation procedure. Anesthesia time was 510 min, cardiopulmonary bypass time – 298 min, aortic cross-clamping time – 229 min, and 30 min of 19°C circulatory arrest. Transfusion of eight doses of freshly frozen plasma (FFP), four doses of red cell suspension, six doses of platelet concentrate was performed intraoperatively, and a device for autologous blood reinfusion was used. Postoperative period was complicated by multiple organ failure including acute lung injury (25 days of mechanical ventilation), cardiovascular failure (11 days of inotropic support), acute ischemic stroke, severe hospital acquired pneumonia. On 37th day the patient was transferred to the surgery ward, and on the 70th one he was discharged from the hospital.

Keywords: Crossbow; Chest Injury; Heart Injury; Autotransplantation

Abbreviations: BP: Blood Pressure; HR: Heart Rate; CVP: Central Venous Pressure; MSCT: Multispiral Computed Tomography; RVOT: Right Ventricular Outflow Tract; FFP: Freshly Frozen Plasma; PAP: Pulmonary Artery Pressure; BAL: Bronchoalveolar Lavage

Introduction

The first mention where the arrows were using as a weapons dated back to the 10th millennium BC, the late Paleolithic era. Even then, being made of bone and flint, the arrowheads developed sufficiently high kinetic energy for defeating both large and small animals. Due to development of medicine there were found various methods of treatment and complication avoidance, though in ancient times wounded, as a rule, doomed to die. Hippocrates of Kos (460-375 BC) was sure about the success of minimal surgical wound treatment and offered to leave an arrow in the body until its suppuration with subsequent extraction. Hippocrates IV, the nephew of Hippocrates of Kos, removed arrows from the wound using a special device - Diocles' curette spoon, which allowed to avoid large incisions for the tip search. Cornelius Celsus (30 BC - 50 AD) offered the removal of arrows through contrapertures on the opposite side of the body - per expulsionem. This allowed to reduce damage to internal organs during mobilization of the boom through the inlet. Arab healers of the Middle Ages (Razes, Albukasim, Avicenna) were convinced of the arrow's fastest

removal effectiveness from the wound in order to avoid suppuration. Ambroise Pare (1510-1590) first proposed the methods of initial surgical debridement of wounds with the evacuation of exudate and disinfection with antiseptics - brandy and vinegar.

In 1882, the American military surgeon Joseph H. Bill published a series of works, formulating 7 basic rules for the arrow's injury treatment:

1. The tip must be removed as soon as possible.
2. Large cuts may be reasonable in order to find the tip.
3. The broom can be removed from the inlet as well as pushed through and removed from the other side of the body.
4. Using a finger to examine the wound channel prevails over the using of the probe.
5. Caution is necessary to be careful in order to prevent boom's breaking off.
6. Healing by the first intention is most preferable.
7. The surgeon must alleviate the suffering of the wounded, for a wound with an arrow brings a significant drop in the spirit of a warrior [1,2].

The arrow consists of a tip, a shaft and plumage. The shaft of modern arrows, as a rule, is aluminum or composite. Tips are made of steel, it can be training (sports) one and hunting one. The training tip is cone-shaped, resembles a bullet, and its diameter is equal to the diameter of the shaft. The hunting tips are characterized by the presence of "petals'' with a sharp, cutting edge to enhance the damaging effect. A sports boom has moderate kinetic energy about 3 times less than that of a bullet fired from a pistol. The initial speed of the boom of modern bows and crossbows varies from 40 to 120 m / s. After penetrating the tissues a wounding shell of a sports boom provides a "tamponing effect" so the massive bleeding doesn't occur [1-3].

In modern descriptions of all traumatic injuries, penetrating wounds with aortic damage are modest 0.3%. However such injuries lethality reaches 80-86% according to various authors [4-6]. We were able to find only one described case of a penetrating wound by an arrow with damage to the aorta in the Pubmed bibliographic database. The patient was admitted to the hospital conscious 12 hours after the injury. Hemodynamics was stable, initial hemoglobin 129 g / l. During the wound revision, the marginal defect of the ascending aorta was found and closed. The patient was transferred from the ICU on the 5th day [7]. Fingleton et al. analyzed the treatment of 63 patients with thorax and abdomen wounds by arrows in New Guinea, where tribal wars were still taking place. 44% of the wounded arrived stable and conscious. The postoperative period was described only in 13 patients, and 2 of them died [8].

Case Report

A 53-year-old patient was urgently admitted to the Almazov National Medical Research Centre from a city hospital with an initial diagnosis: multiple penetrating wounds perforating the chest (Figure 1). The patient was taken to the operating room by the ICU staff and the surgical ones, without entering the admission department. On initial examination clear conscious, hemodynamics is stable, without inotropic and vasopressor support. Blood pressure (BP) 100/60 mm Hg, heart rate (HR) 89 min-1, central venous pressure (CVP) 12 mm Hg. Oxygenation was slightly impaired, SaO_2 - 95% while breathing room air. According to the patient, it's been 36 hours since he shot himself in the chest with two arrows from a crossbow in order to suicide. According to the data of the chest multispiral computed tomography (MSCT), performed earlier in the city hospital, penetrating wound of the chest with two foreign bodies 28 and 25 cm long, 9 mm in diameter, metal density with a cavity inside and with a solid cone-shaped tip were found. Bilateral hemothorax. Hemopericardium.

Figure 1: A patient injured by two arrows of a crossbow. The photo was taken in the city hospital before the chest multispiral computed tomography.

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The first arrow pierced through the right ventricular outflow tract (RVOT), the aortic root, the right and the left sinuses of Valsalva, the cusp of the aortic valve, through the left atrium and the descending aorta. Then through the left half of the Th_{IX} vertebra's body, with the damage to the left transverse process, the arch and the spinal canal, without violating the integrity of the spinal cord. The wound tract ended in the soft tissues of the back, leaving through the skin (Figures 2 & 3). The second arrow entered the left ventricle through the RVOT, then pierced through the interventricular septum with the destruction of the mitral valve. Passing 5 mm from the descending aorta through the base of the left lung went into the soft tissues of the back with damage to the transverse process of the Th_{X} vertebra and neck of the IX rib, ending in the back's subcutaneous fatty tissue (Figures 4 & 5).

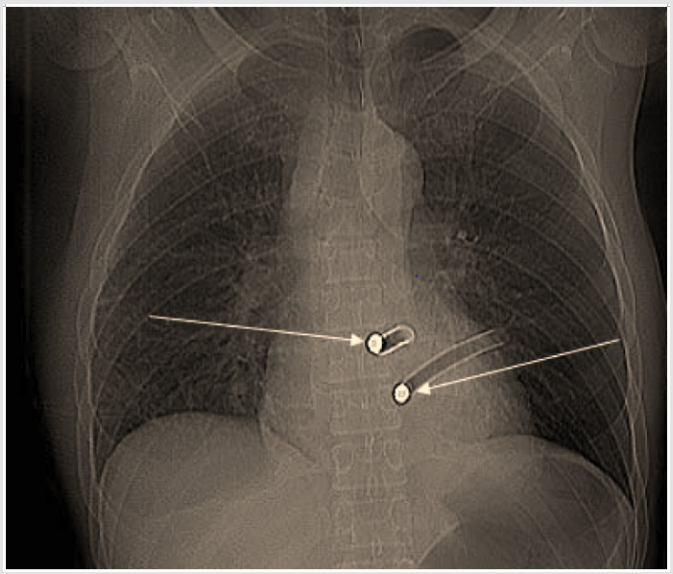

Figure 2: Plain panoramic frontal chest X-ray, foreign bodies (arrows) are marked.

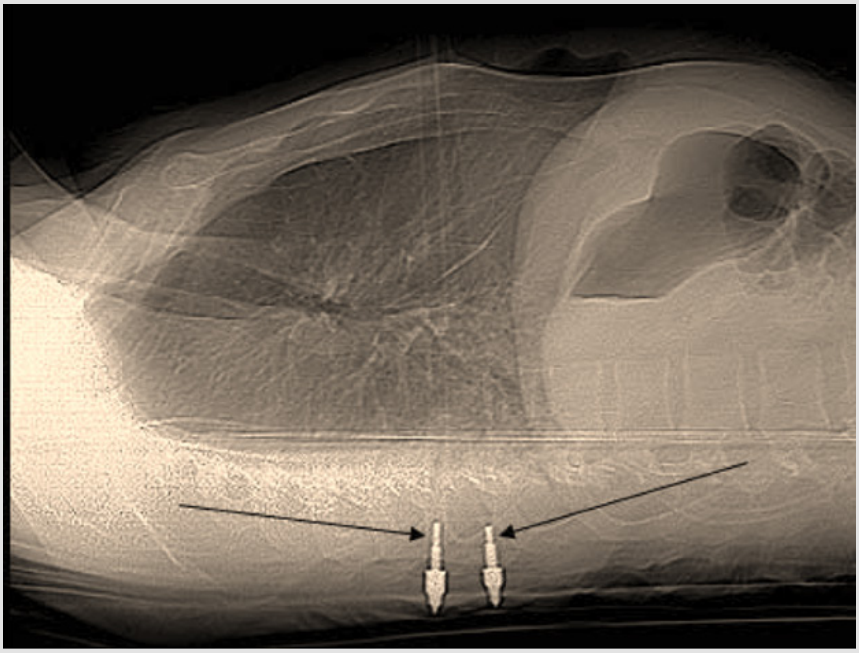

Figure 3: Panoramic chest X-ray in a lateral projection, foreign bodies (boom tips) are marked.

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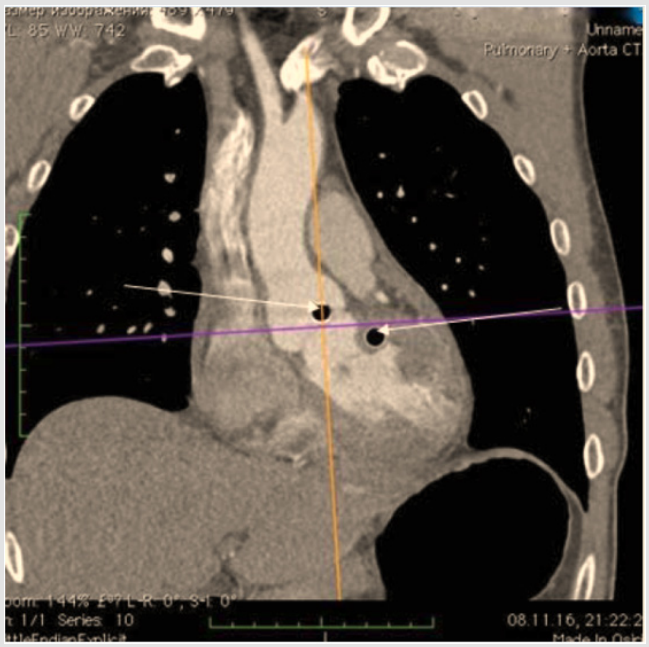

Figure 4: Chest CT, foreign bodies (booms) are marked.

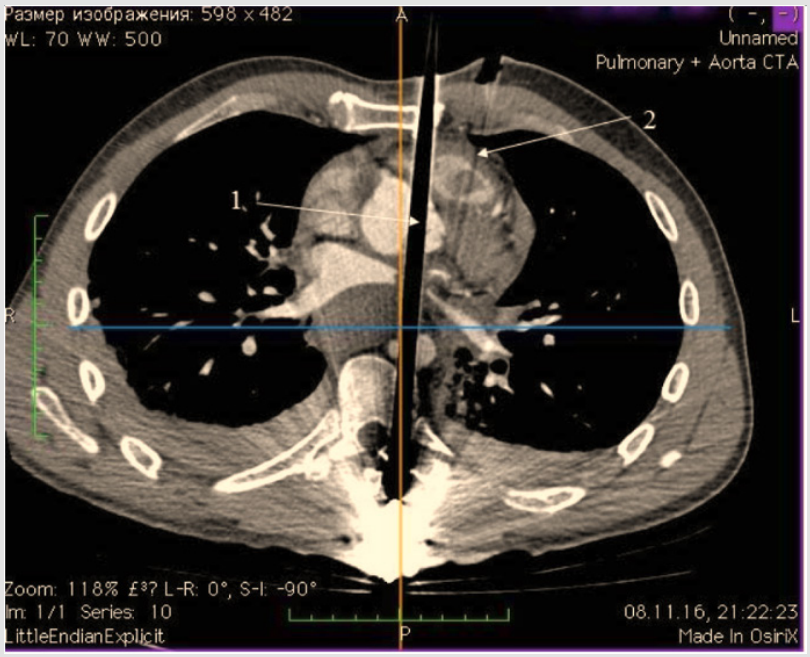

Figure 5: Chest CT, foreign bodies (booms) are marked.

Surgery was performed under general combined anesthesia based on sevoflurane (inhalational, 1,5 - 2,0 vol.%, Sevorane®). In addition to basic monitoring, pulmonary artery catheterization using a Swan- Ganz catheter, transesophageal echocardiography and cerebral oximetry based on near-infrared spectroscopy (NIRS) were used. The arrows were tightly fixed in the sternum, which required some efforts from surgeons to keep the main axis of the arrows in the wound deep layers to avoid massive bleeding Peripheral cannulation for the cardiopulmonary bypass was performed according to the following scheme: the right subclavian artery - the right atrium (the cannula was installed through the right femoral vein). For the purpose of anti-ischemic protection, cold pharmacological cardioplegia based on the Custodiol solution was used and injected antegrade selectively into the mouths of the coronary arteries and retrograde through the coronary sinus.Closure of a descending aortic defect required complete circulatory arrest in conditions of deep (19°C) hypothermia lasting 30 minutes.

Considering the multiple heart chambers and aorta damages (12 injuries), it was decided to remove the heart from the pericardium, close the defects, replace the mitral valve, perform the reconstructive surgery on the aortic valve with subsequent autotransplantation of this heart. The anesthesia lasted 510 minutes, cardiopulmonary bypass - 298 minutes, the aorta was cross-clamped for 229 minutes, and 19°C circulatory arrest lasted 30 minutes. Transfusion of eight doses of freshly frozen plasma (FFP), four doses of red cell suspension, six doses of platelet concentrate was performed intraoperatively, and a device for autologous blood reinfusion was used. When patient was admitted to the ICU hemodynamics was relatively stable under inotropic and vasopressor support: BP 90/53 mmHg, HR 110 min^{-1}, CVP 15 mmHg, pulmonary artery pressure (PAP) 34/15 mmHg, Cardiac Index (CI) 2.8 $l/min/m^2$. The patient needed high doses of inotropic and vasopressor: epinephrine (0.5 μg/kg/min, IV Adrenalin®), norepinephrine (0.7 μg/kg/min, IV Noradrenalin®), dobutamine (10 μg/kg/min, IV Dobutamin Admeda®). According to the acid-base state of the blood, metabolic lactate acidosis (pH 7.11, lactate 19 mmol/l) was detected. Echocardiography data revealed the LVEF was 50% with a severe hypokinesia of the right ventricle and moderate aortic regurgitation.

The postoperative period was complicated with multiple organ failure. Acute respiratory failure required mechanical ventilation for 25 days with tracheostomy performed on the 6th day. There were inotropic and vasopressor support for 11 days to correct the cardiovascular failure. Day 2, the patient had recurrent seizures, coped with diazepam (10 mg, IV Sibazon®), with a further switch to prolonged sodium thiopental sedation (2,5 mg/kg/h, IV Sodium thiopental-Sintez®). MSCT of the brain revealed signs of acute ischemic stroke in the region of the left middle cerebral artery. Out of patient sedation, the right-sided hemiparesis was observed. From the 8th day a regaining of consciousness and motor activity was noted, resulting in switching to assisted respiratory support. A conspicuous component of intensive care, which largely determined the present case outcome, was the treatment of infectious complications. Antibacterial therapy was prescribed in strict accordance with the biomaterials microbiological tests data. The origin of the injury and the suspected mediastinitis forced to prescribe an extended antibiotic therapy based on linezolid (10 mg/kg every 8 h, IV Linezolid®) and meropenem (1000 mg every 8 h, IV Meropenem®) immediately after admission. On the third day of treatment, the first sampling microbiological tests were performed, resulted in detection of Staphylococcus epidermidis derived from bronchoalveolar lavage (BAL), but the blood and the urine were sterile. Day 6, left-sided lower lobar pneumonia developed, and a carbapenemase secreted pan-resistant strain of Klebsiella pneumoniae was detected in BAL. According to a histopathological analysis of the surgical material, signs of endocarditis were detected, at this stage antibiotic therapy was expanded with the addition of polymyxin (2,5 mg/kg, IV Polymyxin B®). Day 16, a gram-negative bacillus of Elizabethkingia meningoseptica in combination with the previous Klebsiella pneumonia strain was detected in the BAL and polymyxin (200 mg/day, IV Polymyxin B®) was added to the therapy. On the 20th day, urine culture revealed Candida albicans which required the prescription of anidulafungin (200 mg in day 1, then 100 mg/day, IV Eraksis®). On the 23rd day, a worsening of the patient's condition with polysegmental infiltration of the right lung on the X-ray and the respiratory failure. Piperacillin + tazobactam (4 g + 0,5 g every 8 h, IV Piperacillin+tazobactam®) was added to therapy. This drug combination lasted for 10 days with a positive effect as a regression of the pneumonia. On the 25th day, tracheal decannulation was performed. After the 37^{th} day the patient was transferred to the surgery ward. On the 70^{th}, the patient was discharged from the hospital with a clinical picture of moderate aortic insufficiency. In 4 months, the patient underwent planned replacement of the aortic valve and the tricuspid valve repair. The patient was transferred to the surgery ward the day after surgery. After a month, the second step was to implant a pacemaker.

Discussion

The represented clinical case demonstrates the facilities high-tech assist to a patient with extremely severe multiple damages to the heart and aorta. Wherein there are three critical stages in treatment: the extremely complex and traumatic surgical intervention, multiple organ failure in the postoperative period and the extremely aggressive, multiresistant hospital infection, which is typical for ICU today. This clinical case is an example of a quite common to modern cardiac surgery phenomenon: due to effective technologies, patients survive severe complex interventions and hemodynamic disturbances, and the postoperative period with the inevitable development of multiple organ failure becomes the most complicated problem. Another distinctive modern hazard is a multiresistant hospital infection, which in itself could cause the death of the patient.

Conclusion

Modern cardiac surgery techniques and intensive care approaches achieve survival in patients with severe multiple heart and aorta injuries.

Conflict of Interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

The authors report no involvement in the research by the sponsor that could have influenced the outcome of this work.

All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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