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ASYSTOLE KIDNEY DONATION USING AUTOMATED CHEST COMPRESSION SYSTEM AND HYPOTHERMIC OXYGENATED MACHINE PERFUSION (FIRST EXPERIENCE IN THE RUSSIAN FEDERATION)

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Objective: to demonstrate, using a clinical case, the first successful experience in a combined use of an automated chest compression device (ACCD) and hypothermic oxygenated machine perfusion (HOPE) for kidney transplantation from a donor with irreversible cardiopulmonary arrest. **Materials and methods.** In the presented clinical case, ACCD was successfully used in a donor who was pronounced dead following an irreversible cardiopulmonary arrest. This allowed to minimize the primary warm ischemia time. Kidney graft HOPE for 585 minutes reduced the static cold storage time to 165 minutes. **Results.** In the uneventful postoperative period, there was immediate kidney graft function. This allowed for rapid rehabilitation and discharge from hospital. **Conclusion.** Introduction of ACCD and HOPE will increase the number of donor organs, mainly kidneys intended for transplantation.

Keywords: kidney transplantation, automated chest compression device, organ donation, hypothermic oxygenated machine perfusion.

INTRODUCTION

Donation after circulatory death (DCD) is a well-established practice in many countries. Currently, 18 of 35 countries in Europe use DCD donors, of which 8 use only DCD donors after sudden cardiac arrest, the so-called uncontrolled asystole donors [1]. At the same time, the potential use of such donors is huge. For example, it has been estimated that the use of DCD donors after cardiac arrest in the U.S. can attract up to 22,000 additional potential organs per year [2]. A significant increase in cases of primary nonfunctioning grafts and grafts with delayed function is the reason for limited use of organs from DCD donors [3–5]. Moreover, the success of kidney grafts donated after circulatory death depends not only on the technical execution and perioperative management of the recipient, but also on the effective logistics of interaction between donor centers and kidney transplant centers [6]. Modern logistics of DCD is quite complicated, requiring high organization of the donor process, use of additional modern features – ACCDs, hypo- or normothermic perfusion of organs in situ, as well as machine perfusion of donor organs at the final stage [7]. The mentioned limitations, logistical and technological difficulties lead to the fact that only 17 effective DCD donors were registered in the Russian Federation in 2020 [8].

The development of modern protocols for post-ischemic rehabilitation of kidney grafts using the latest technology will expand the pool of DCD donors with sudden cardiac arrest.

CLINICAL CASE

Effective donor: male, 43 years old, diagnosed with penetrating head injury, severe cerebral contusion, and acute subdural hematoma on the left frontoparietal temporal region with 150 cm^3 volume. Decompressive skull trepanation was carried out, the hematoma was removed on November 29, 2021. Alcohol intoxication. The length of in-hospital stay from the moment of admission to the date of death was 27 hours. In the postoperative period, there were hypotension and sinus tachycardia with 121 bpm heart rate, which required adequate volemic support and intravenous norepinephrine administration at 890 ng/kg/min dose. The patient's level of consciousness corresponded to 3 points on the Glasgow Coma Scale (GCS). However, there was positive tracheal reflex, which made it impossible to diagnose brain death. By the end of day 1 of stay at the hospital, the patient's hemodynamic indicators were getting worse – hypotension was increasing, thus, vasopressor support increased to 1700 ng/kg/min. The patient suffered a cardiac arrest on November 30, 2021, at 4 pm; ACCD resuscitation was initiated. The resuscitation lasted 30 minutes with-

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out any effect, subsequently he was pronounced dead. After death, the ACCD was continued to provide minimal perfusion of organs and tissues as an anti-ischemic protection. Mechanical ventilation with an FIO_2 of 100% was also initiated. Against the background of the ACCD, surgical access to the right femoral vessels was performed, the femoral artery and vein were isolated and taken on a holder. The femoral artery lumen was opened and a double-balloon triple-lumen catheter (DBTL catheter) with 22 Fr lumen diameter was inserted into the femoral vein; a 24 Fr venous cannula was inserted into the femoral vein lumen to drain the perfusate. Cold isolated perfusion of the abdominal organs with Custodiol preservative solution was initiated. At the start of cold perfusion, mechanical ventilation and automatic chest compression were terminated. Operation of the ACCD lasted for a total of 58 minutes, which included 30 minutes of resuscitation. The ACCD operation and appearance of the kidneys at the end of in situ perfusion are shown in Figs. 1 and 2, respectively.

Kidney graft: *The kidney graft was delivered in a transport container by a team from Moscow Organ Donation Center to Botkin Hospital at 7 pm on November 30, 2021. At 7:15 p.m., the graft was removed from the container, and perfusate was taken for microbiological examination. On examination, the left kidney graft was of medium size, homogeneous color, without tumor-like masses. The only renal artery extending from the aorta and the only renal vein were identified. The proximal renal artery was mobilized, no atherosclerotic plaques were detected at the orifice. The doctors decided to initiate HOPE. Centrifugal blood pump Maquet Jostra was prepared. The renal artery was cannulated (Fig. 3), HOPE was initiated at 7:45 pm (static cold storage time was 135 minutes).*

Renal graft temperature before perfusion was 8.9 °C, perfusion solution pressure in the renal artery was 40 mmHg, perfusion solution volume rate was 200 mL/min, and vascular resistance index was 0.2. HOPE time was 585 minutes. During this period, renal graft temperature did not increase above 6 °C (Fig. 4).

Perforating solution pressure during the procedure was maintained at 40 mmHg. Volumetric flow rate at the end of the procedure was 250 mL/min, vascular resistance index was 0.16. Partial pressure of oxygen in perfusion ranged from 337 to 591.

Fig. 1. ACCD operation after the patient had been declared dead

Fig. 2. Donor kidney after in situ cold perfusion

After the skin incision in the recipient has begun, machine perfusion was suspended. Pre-transplantation preparation of the renal graft was 30 minutes (total static cold storage time was 165 minutes).

Renal transplant recipient: *After cross-matching and donor typing, donor-recipient pairing was performed at 10 pm – recipient B, 41 years old, suffering from chronic kidney disease as a result of IgA nephropathy. He had been under long-term hemodialysis since June 2018 (A, B, Dr match). The patient had been waitlisted for 19 months. He was admitted at Botkin Hospital at 01:00 am. On December 01, 2021, during preoperative examination, he was diagnosed with high blood potas-*

sium (up to 6.9 mmol/l), which required preoperative hemodialysis for 3 hours.

The surgical intervention was initiated on December 1, 2021, at 5:30 am according to standard technique. After blood flow was initiated, the graft acquired physiological turgor, evenly turned pink, and urine flow through the ureter was noted (Fig. 5).

After suturing the anterior abdominal wall muscles, intraoperative ultrasound examination was performed, which revealed satisfactory arterial (resistance index 0.77) and venous blood flow (Fig. 6).

The postoperative period was uneventful. There was immediate kidney graft function. Creatinine levels normalised on postoperative day 6. After the immunosuppressive dose had been selected and the internal ureteral stent removed, the patient was discharged for outpatient follow-up.

DISCUSSION

Over the past 5 years, the number of effective donors per million population in Moscow has doubled (11.4 in 2016, 21.4 in 2020). This was mainly due to an increase in the number of brain-dead donors. Improvements in organ donation allowed to open new kidney transplantation centers in the metropolitan area [9].

Meanwhile, there was no active use of DCD during this period of time. This is due to the fact that prolonged primary warm ischemia of renal grafts obtained from donors after cardiac arrest and then prolonged static cold storage significantly worsen the immediate and long-term outcomes of kidney transplantation. Therefore, shortage of donor organs prompts researchers to search for a solution to minimize warm and cold ischemia time and widen their use in transplantation practice.

Modern automated chest compression systems have proven themselves well in pre-hospital and hospital phases as simple and reliable devices that can be used to provide quality and long-term maintenance of sufficient blood supply to vital organs, allowing patients to be delivered to the hospital. This system has attracted the attention of many donor programs around the world, including the Moscow City Organ Donation Center because of its ability to maintain blood supply for a long time. The use of this system in DCD minimizes primary warm ischemia time of renal grafts, allows for cannulation of the great vessels and initiation of cold perfusion under technologically acceptable conditions.

After completion of in situ perfusion of the organ in the donor's body, the organ enters the stage of static cold

Fig. 3. HOPE under the supervision of a transplant surgeon

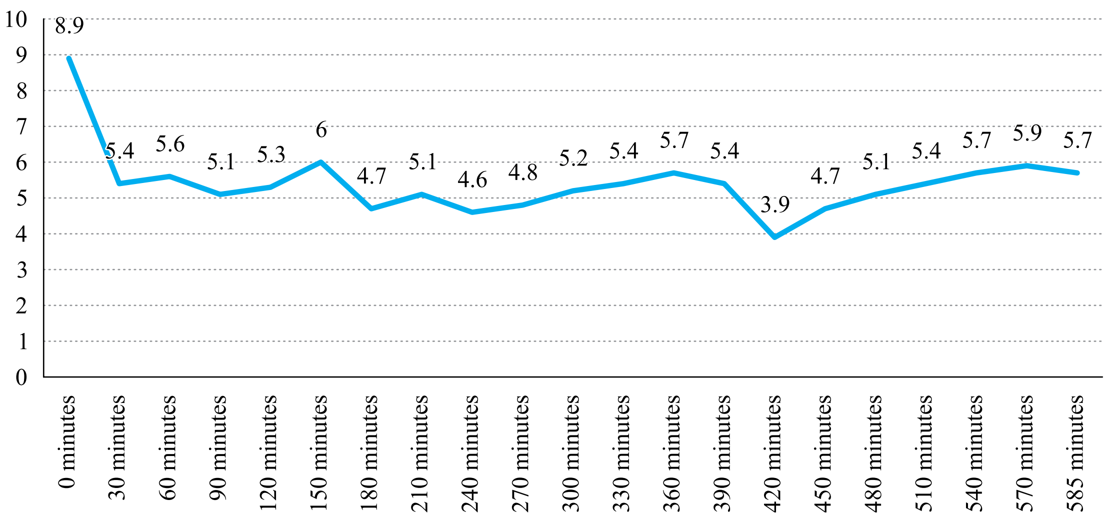

Fig. 4. Dynamics of renal graft temperature during HOPE

storage and remains in this state until it is incorporated into the recipient's bloodstream. During cold storage, the donor is subjected to virological and genetic examination, which can take 6 or more hours. Thus, the total static cold storage time is most often between 12 and 18 hours, and in some cases, it may exceed this. As is known, nearly 95% of cellular adenosine triphosphate (ATP) is depleted within 4 hours of static cold storage, and the latter switch to anaerobic metabolism [10]. This leads to accumulation of reactive oxygen species, development of intracellular acidosis, decrease in Na,K-ATPase, eventually causing apoptosis.

The introduction of HOPE – a technology that allows the delivery of oxygen required to maintain minimal metabolic processes over a long period of time – into wide clinical practice at Botkin Hospital may allow mitigating these negative aspects of the use of kidneys donated after circulatory death.

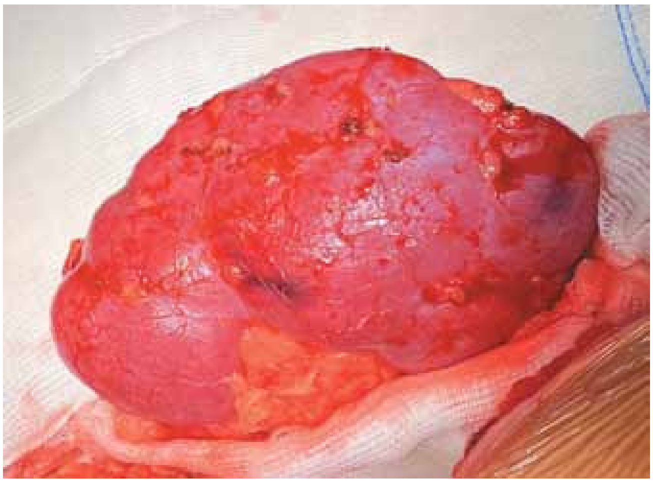

Fig. 5. Renal graft after reperfusion

Our first experience has demonstrated the positive aspects of the combined use of modern technologies to mitigate renal ischemia injury. ACCD allowed to reduce the negative effect of primary warm ischemia, while the use of HOPE reduced the static cold storage time to 165 minutes and facilitated post-ischemic rehabilitation. The immediate kidney graft function, uneventful postoperative period and early rehabilitation of the recipient convinced the staff at the Organ Donation Center and Botkin Hospital Transplantation Center to continue to carefully analyze the new practice of asystolic kidney donation.

The success of kidney transplantation depends on the work of the medical staff from the donor conditioning stage to perioperative management of the renal graft recipient. The multidisciplinary approach allows us to minimize the possible risks of kidney transplantation, which is also a strong reason by kidney transplant recipients to choose this approach over other renal replacement therapy methods. The introduction of modern techniques at each of the stages only helps in the implementation of this task.

CONCLUSION

The combined use of ACCDs and HOPE when using organs donated after circulatory death allows to minimize primary warm ischemia time and static cold storage time, thereby mitigating their negative effects on renal graft function. Further application of this protocol allows us to reasonably expect an increase in the number of donor organs for transplantation purposes.

The authors declare no conflict of interest.

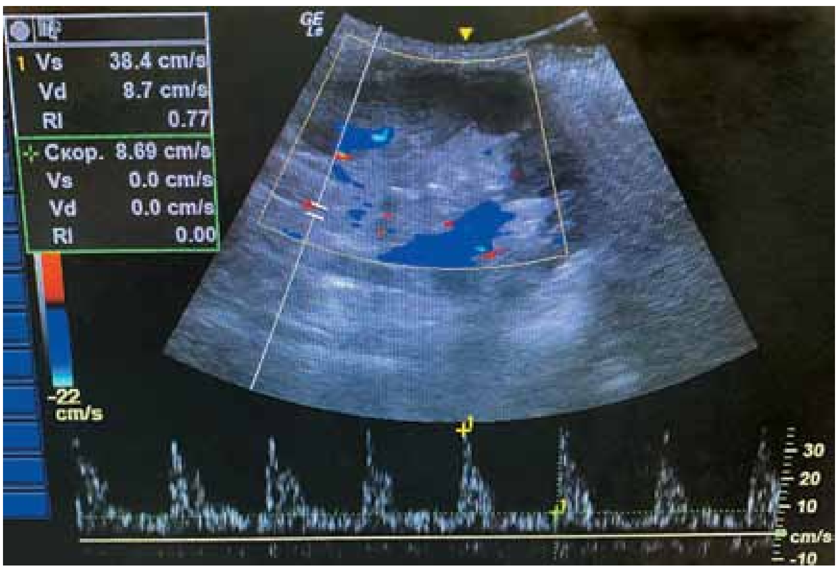

Fig. 6. Intraoperative kidney graft ultrasound

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