Appendix 1

Details of the MDT model

The transplant nurse-led multidisciplinary collaborative nursing protocol was developed as follows.

The MDT members' responsibilities

The transplant nurse was responsible for nursing team building, nursing protocol development and quality control, and cross-disciplinary coordination; the transplant surgeon was responsible for treatment protocol decision-making and recommendation; the anesthesiologist was responsible for choosing the anesthesia mode, formulating an anesthesia plan, offering precise anesthesia, implementing intraoperative fluid management, and identifying and handling anesthesia emergencies; the hemodialysis physician was responsible for assessing volume status and maintaining volume balance; the hemodialysis nurse was responsible for maintaining vascular access ports, assessing patients' response to hemodialysis treatment (including the vital signs, fluid balance, and circulation stability), and providing feedback to the transplant nurse; the nutritionist was responsible for formulating personalized nutrition management plans; the rehabilitation physician, diabetes specialist nurse, and pharmacist offered consultations for difficult problems in their own specialty areas; and the follow-up nurse was responsible for post-discharge follow-up management and data collection.

Preoperative assessment and preparation

Members included a transplant surgeon, a transplant nurse, an anesthesiologist, operating room nurses, and a hemodialysis nurse. (I) The transplant surgeon strictly evaluated the surgical indications, preoperative general conditions, and cardiopulmonary function according to the requirements in the *Clinical Technical Specification for Simultaneous Pancreas and Kidney Transplant* and formulated the preoperative dialysis plan together with the dialysis physician based on the patient's water, electrolytes, and acid-base balance. (II) The anesthesiologist and the theatre nurses thoroughly assessed the patient's anesthesia risk. (III) The transplant nurse offered preoperative preparation and psychological care for the patients based on the results of preoperative assessment performed by the MDT.

Intraoperative management

Intraoperative management was participated by a transplant surgeon, an anesthesiologist, and operating room nurses. The transplant nurse handed over the patient's preoperative assessment and preparation conditions to the operating room nurses, focusing on the special medical histories and the MDT's preoperative assessment results (including cardiopulmonary function and dialysis status), so as to enable the operating room nurses to monitor and maintain effective circulation and carry out fluid management, thus ensuring the intraoperative safety.

Postoperative management

(I) Condition observation

Monitoring was performed by the transplant team-directed MDT. (i) Changes in disease conditions were close monitored. The vital signs and central venous pressure were monitored on an hourly basis, with special attention to changes in blood pressure, heart rate, and heart rhythm. Post-transplant hypotension increases the risk of arterial graft thrombosis. The post-operative blood pressure should not be too low, and the systolic blood pressure should be maintained at 120–160 mmHg to ensure effective perfusion of the kidney and pancreas grafts and prevent oliguria secondary to hypotension or even delayed recovery of renal function and thrombosis. (ii) The wound dressings were observed, and the presence (or absence) of tenderness, distension, and/or tension in the transplantation area were assessed. The perirenal drainage tube, posterior pancreatic head drainage tube, vesicorectal pouch drainage tube (pouch of Douglas drainage tube in women), and gastric tube were placed after surgery for gastrointestinal (GI) decompression. All the tubes were fixed and in good condition. The drainage should be sufficiently patent. The volume, color, and properties of drained fluids were observed. (iii) During the daily medical and nursing integrated ward rounds, the transplant nurse performed 3-level quality control. Solutions to the major nursing issues were proposed according to changes in the disease conditions, which provided clear nursing guidance for clinical nurses.

(II) Fluid management

Goal-directed fluid therapy was applied to minimize cardiac workload, maintain effective circulating volume, and ensure tissue and organ perfusion. Fluid infusion was guided by the real-time, accurate, and continuous hemodynamic and volume

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monitoring. (I) The 24-hour fluid intake and output were accurately recorded after surgery. (II) The individualized fluid therapy protocols were developed on a daily basis based on the preoperative dialysis type, age, body weight, cardiac function, urine output, blood pressure, central venous pressure, and intraoperative fluid intake and output. Fluid management was dynamically adjusted when necessary. (III) The infusion of daily target ordered volume was required to be completed in each shift. (IV) The specialist quality indicators for fluid management were developed for each post-transplant patient, with an attempt to achieve optimal volume management through indicator-based quality control.

(III) Blood glucose management

Blood glucose is an important monitoring indicator after SPKT and can be used to intuitively assess the function of the pancreas. The postoperative blood glucose management program was jointly developed by the transplant nurse and the diabetes specialist nurse: (i) an instantaneous scanning glucose monitoring system was used for painless, rapid, accurate, continuous, and dynamic blood glucose monitoring. (ii) The blood glucose was monitored every hour from the day of surgery to the second postoperative day and then every 2–3 h on the third postoperative day. Then, the monitoring frequency was changed to before meals and 2 h after meals after the patients resumed eating by mouth. (iii) Special attention was paid to the occurrence of hyperglycemia or hypoglycemia: Postoperative emergency and high-dose hormone use may lead to stress-triggered elevation of blood glucose in a small number of patients. The possibility of delayed pancreatic graft function should be considered if there is refractory hyperglycemia. Thrombosis of the transplanted pancreas and/or graft pancreatitis should be ruled out, and early identification and early intervention are required if such conditions are present. Since the endocrine drainage method used in the surgery was based on systemic circulation and insulin does not circulate through the liver, some patients may experience hypoglycemia. Thus, the blood glucose needs to be closely monitored and managed in time.

(IV) Nutrition management

Personalized and phased nutritional support programs were developed for patients. (i) After SPKT, a gastric tube was placed for GI decompression for 5–7 days, and total parenteral nutrition (TPN) [25–30 kcal/(kg·d)] was offered. (ii) After the removal of the gastric tube, TPN was gradually transited to a full liquid diet and then a normal diet. (iii) The transplant surgeon, transplant nurse, and nutritionist closely cooperated to conduct a comprehensive nutritional assessment based on the patient's body mass index (BMI), total serum protein, and hemoglobin and according to the *Nutritional Risk Screening 2000* (NRS 2000). The nutritional programs were dynamically adjusted. TPN should be transited to a combination of enteral and parenteral nutrition. When transoral feeding could meet 60% of the target caloric requirement, parenteral nutrition was stopped and total enteral nutrition was offered. (iv) During the period when the patient resumed transoral feeding, the nursing priorities were changed to abdominal signs and GI reactions; blood and urine amylase, serum lipase, electrolytes, and blood glucose should be monitored, and any possible complications such as GI bleeding and intestinal infarction should be observed.

(V) Optimization of immunosuppressive regimen

Immunosuppression after SPKT must be individualized as much as possible under the premise of good function of the transplanted pancreas and kidney. (i) The immunosuppression regimen shall be customized according to the body weight, age, and metabolic type. (ii) An immunosuppression regimen based on tacrolimus + mycophenolate mofetil + hormones was used, and rabbit anti-human thymoglobulin and interleukin 2 (IL-2) inhibitors were used for immune induction. (iii) Drugs were administered via gastric tube during gastric tube placement, and GI decompression was continued after the gastric tube was clamped for 2 hours after drug administration. (iv) The blood concentration of tacrolimus was measured twice weekly. The immunosuppressant dosages were promptly adjusted according to drug concentration to maintain blood concentration at 5–15 ng/mL. (v) Priority was given to ensure proper drug administration, optimize patients' awareness and behavior, and broaden patients' drug knowledge.

(VI) Infection control and prevention

Strict infection control and prevention measures were applied. (i) Adequate preoperative bowel preparation was conducted to reduce abdominal contamination during intestinal surgery. (ii) After the surgery, the patients were transferred to the intensive care unit (ICU) for protective isolation, and the sheet and clothes were sterilized by using pressurized steam. (iii) 2% chlorhexidine wipes were applied to bath the patients; during the placement of the gastric tube, the mouth was rinsed with 0.9% saline and 5% sodium bicarbonate injection in an alternating manner; perineal wiping was per during the placement of indwelling urinary catheter, and skin cleanser was used to prevent incontinence-associated dermatitis. (iv) potential pathogens

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in the patients' secretions, drainage fluids, and excretions were regularly detected, and any abnormalities detected were intervened promptly. (v) Antimicrobials were rationally used.

(VII) Management of complications

The transplant surgeon and the specialist nurses were the key members of the complication management team. Evidence-based integrated prevention strategies for pulmonary infection, urinary tract infection, and abdominal infection were developed. The common complications and their management were as follows: (i) rejection: distension and tenderness in the transplantation area were investigated and the tension was observed; changes in body temperature, blood sugar, blood and urine amylase, lipase, and other indicators were monitored; changes in stool form were observed; and auxiliary examinations such as color ultrasound of pancreas graft, abdominal computed tomography (CT), and pancreas puncture biopsy were performed if necessary. (ii) Postoperative bleeding: The main causes of intra-abdominal bleeding after SPKT are abnormal coagulation function in uremic patients, routine postoperative anticoagulation therapy, graft pancreatitis, and local infection. The patients' blood pressure and heart rate should be closely monitored, and the color and volume of drainage fluids should be observed. The anticoagulant drugs should be rationally used, and any bleeding tendency should be observed. (iii) Pancreatic fistula and intestinal fistula: pancreatic fistula is characterized by changes in color and nature of drainage fluid and significant elevation of amylase and lipase levels, along with increased body temperature in patients with infection. Intestinal fistula is characterized by severe abdominal pain, abdominal distension, peritoneal irritation, and other manifestations of peritonitis, accompanied by fever, elevated white blood cell count, and drainage of fecal residue-like fluid (drainage fluid obtained by abdominal puncture is brown and has a fecal odor). Free gas can be seen on imaging. Immediate surgical intervention should be offered once a diagnosis of pancreatic fistula or intestinal fistula is confirmed. (iv) Pancreas graft thrombosis: It has insidious early manifestations, including elevated blood glucose as well as elevated blood and urine amylase and lipase levels. In the more advanced stages of pancreas graft thrombosis, the blood and urine amylase and lipase levels sharply decrease, along with pain or tenderness in the transplantation area. The diagnosis can generally be confirmed by Doppler ultrasonography, although CT or magnetic resonance imaging (MRI) angiography can also be valuable. (v) Graft pancreatitis: The typical signs and symptoms include pain in the abdominal wall at the transplant site, abdominal distension, tenderness, and significantly elevated blood and urine amylase levels. Graft pancreatitis should be distinguished from pancreatic fistula; a drainage fluid amylase level of up to 10,000 U often suggests pancreatic fistula. (vi) Intestinal obstruction: Intestinal obstruction is related to long operative time, severe edema of the intestinal wall, history of preoperative peritoneal dialysis complicated by peritonitis, GI dysfunction, and unreasonable diet. Its clinical manifestations include nausea, vomiting, abdominal distension, and delayed defecation. The transplant nurse should preemptively identify potential nursing problems. In this study, the transplant nurse organized joint rounds by the MDT to achieve the early diagnosis, treatment, and nursing of these complications, so as to lower the incidence of complications and increase the survival rates of both grafts and patients.

(VIII) Early rehabilitation and functional exercises

In order to promote early rehabilitation and prevent pulmonary infections, individualized physical and mental preparation was completed according to patients' cognitive ability and psychological status (11) and rehabilitation exercise plans were developed and implemented: (i) preoperatively, patients were instructed on respiratory function exercise and bed bowel training. (ii) At post-surgical 2 h, the patients were assisted to turn over, to perform bed extremity extension and flexion exercises, to do ankle pumps, and to receive pneumatic therapy. Patients were also instructed how to cough and spit effectively. (iii) On post-operative day 3–4, the patients began to perform ambulatory activities including respiratory function exercise and limb exercise. (iv) All the exercises were carried out stepwise and individualized. The activities were stopped when the patient experienced discomfort. (v) Through joint rounds, the transplant nurse and the rehabilitation physician comprehensively assessed the postoperative condition of patients, asked the rehabilitation department to assist in rehabilitation exercises according to their conditions, and to jointly formulate rehabilitation exercise prescriptions to promote early postoperative recovery.

(IX) Psychological care

The team aimed to establish a good doctor-patient relationship and learn the psychosocial needs of the patients and their families. Psychological interventions and services were tailored in the different stage of the surgery. For patients with anxiety and/or depression, targeted psychological counseling was offered according to their gender, age, and literacy level. Patients' mental status and emotional reactions were regularly observed, and the postoperative pain, sleep problems, and irritability

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were promptly managed. The patients were also instructed to identify and cope with stress and achieve self-relaxation, and their family members were taught how to provide appropriate mental and somatic care to the patients, thus helping the patients to gain confidence in fighting the disease during the perioperative period.

(X) Health education

Health education empowers patients to take responsibility for their own care and improves their compliance with treatment. In our center, health education was carried out throughout the perioperative period: (i) a clinical nursing pathway for SPKT was established, which covered preoperative awareness raising and postoperative education on infection prevention, functional exercise, medications, diets, observation of complications, self-management, and life- and work-related activities. (ii) The clinical nursing pathway was carried out on a daily basis by the transplant nurse, who conducted the whole-course health education from the preoperative period to the 15th postoperative day. (iii) Health promotion leaflets and popular science videos were created and distributed to improve patients' self-management ability after discharge.

(XI) Continuity of care

The long-term postoperative follow-up visits were arranged. (i) The "Follow-up Management Policies for Simultaneous Pancreas and Kidney Transplant" were established, and dedicated follow-up nurses were designated. (ii) The follow-up frequencies were as follows: within 3 months after surgery: once a week; 3–6 months after surgery: every 2 weeks; and more than 6 months after surgery: monthly. (iii) The content of the follow-up visits included the general condition of the patient, laboratory tests, and color ultrasound findings of the pancreas and kidney grafts. (iv) Both outpatient follow-up and telephone follow-up were applied. In addition, outpatient follow-up by specialist nurses was adopted to provide postoperative evaluation and health education for patients. (v) Health education was also offered with the help of WeChat and other social media and by giving regular health education lectures.

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