12

Perioperative Hydration Policy

Mahmoud M. Othman
Department of Anesthesia,
Urology and Nephrology center,
Faculty of Medicine, Mansoura University,
Mansoura,
Egypt

1. Introduction

The number of Kidney transplants has increased in last decades for many advances in diagnostic and therapeutic reasons. Kidney transplantation results in superior life expectancy and better quality of life if compared to dialysis treatment for patients with end-stage renal failure. The success of graft survival after kidney transplantation is closely associated with early graft function based on intraoperative perfusion characteristics of the allograft and good urine output. Clinicians must carefully adjust intravascular volume and arterial blood pressure to effectively perfuse the graft, and the time course of volume expansion seems important for adequate hydration. The ultimate goal for any renal transplantation patient is to have an optimally functioning graft as early as possible after completion of surgery. Key strategies that are used to achieve this goal involve the optimal management of the intravascular volume and achievement of early urine output. One of the reasons for graft failure after renal transplantation is inadequate graft perfusion caused by mis-management of perioperative hydration policy.

2. Chronic renal failure pathophysiology

Knowledge of the pathophysiologic consequences of chronic renal failure is too important for anesthesiologists, because many of these patients have at least one of these sequences, most commonly hypertension, coronary artery diseases, diabetes mellitus and pulmonary dysfunction. Additionally, disturbance in acid-base, electrolytes and fluid balance are usually related to a marked decline in the glomerular filtration rate (GFR) caused by a variety of systemic diseases such as diabetes mellitus or hypertension, and renal disorders as chronic glomerulonephritis ,cystic kidney disorder ,interstitial nephritis , obstructive uropathy, and lupus nephritis. It is essential to recognize the etiology, because the physician should control the problem and does not rely on the patients' ability to comply with the treatment.

3. Pre-operative Kidney recipient assessment

The practice of anesthesia for kidney transplant requires a thorough understanding of the metabolic and systemic abnormalities in end stage renal disease, familiarity with transplant

medicine and expertise in managing and optimizing these patients for the best possible outcome.

Patients undergoing renal transplant surgery possess several risk characteristics like cardiovascular diseases, hypertension, diabetes mellitus, and the problems of dialysis. Therefore a thorough pre-operative assessment is crucial for successful intra- and postoperative management. The preoperative work-up includes Past- medical history, dialysis evaluation (How long? How often? When was the last dialysis?), serum electrolytes (serum potassium), ECG, chest X-ray and cardiac echocardiography. Dialysis is usually indicated within 24-48 hrs before the operation. Overzealous ultra filtration is best avoided. Volume status is roughly estimated by their dry weight. Decline of more than 2-4 kg during dialysis suggests significant intravascular depletion. Therefore it was advisable to restrict fluid removal during preoperative dialysis to a target of 1-2 kg above the formal dry weight. (Schnuelle and Johannes Van der Woude: 2006). Antihypertensive drugs and cardiovascular medications should be continued until the day of surgery**.**

4. Intra-operative hydration policy

The primary goal of fluid administration is to ensure stable hemodynamics by rapidly restoration the circulating plasma volume. However, excessive fluid accumulation, particularly in the interstitial tissue should be avoided. The intra-operative hydration strategy of both kidney donor and recipient are of paramount important for the insurance the success of kidney transplantation and ensure good function of the graft after surgery.

4.1 Kidney donors hydration policy

Othman and his colleagues (2010) described in their study the hydration regimen of their living kidney donors. The kidney donors, in this study, had received 1500 mls normal saline and 1500 mls Ringer's lactate solution, supplemented by crystalloid titrated to match the urine output from the start of the surgery until the renal vessels were clamped. Kidney donors also received 40 mg furosemide and 150 mL mannitol 10% before nephrectomy.

To maintain good diuresis, fluid administration for kidney donors is usually generous (10-20 ml/kg/hr) using isotonic crystalloids during the intra-operative time (Baxi et al 2009). However, some centers recommend overnight preoperative hydration with intravenous fluids and preloading the patients with colloids just before induction of anesthesia**.** Good hydration of the donor in addition of good hemodynamic intraoperative stability are essential requirements for the graft to tolerate ischemia time after nephrectomy with less harm till vascular anastomosis being completed.

In our center, the harvested kidney in living kidney donor was usually submerged immediately in iced Ringer's lactate solution, and the renal artery was flushed with 250 to 300 mls cold Ringer's lactate solution (4°C) mixed with papaverine 120 mg, heparin 5000 IU, and verapamil 10 mg until the venous effluent was clear (Othman et al, 2010)..

4.2 Kidney recipient hydration policy

Proper peri-operative fluid management is one of the most important aspects governing hemodynamic function in the surgical patient. Adequate hydration is an integral part of the anesthetic management during renal transplant. Adequate plasma volume is essential in maintaining cardiac output and hence tissue perfusion. The stable hemodynamic status of

the recipient during kidney transplant surgery is usually associated with an initial good graft function. To decrease the incidence of postoperative acute tubular necrosis (ATN), a liberal hydration policy is usually employed intra-operatively. The systolic blood pressure is maintained between 130 and 160 mm Hg, and the CVP is maintained between 12 and 14 mm Hg (Ferris et al, 2003). Maintaining adequate CVP is especially important in pediatric recipients because reperfusion of an adult kidney graft after completion of anastomosis may divert a significant amount of cardiac output. Measuring the central venous pressure (CVP) is really an absolute requirement to ensure good plasma volume expansion. The pulmonary artery pressure also can be used to guide fluid therapy in patients with preoperative left ventricular dysfunction (Carlier et al ,1982). Additionally, mean arterial pressure (MAP) less than 100 mmHg and plasma volume below 45 mL/kg at reperfusion of the graft are the usual risk factors for graft failure (Toth et al ,1998). Blood flow to the allograft after reperfusion may predict its immediate function. The early graft function requires adequate perfusion that can be achieved by expansion of the intravascular volume of the recipients.

Recently, a study was designed to examine the time of maximum volume expansion relative to renal ischemia period in living-related recipients and its effect on graft perfusion and early renal function (Othman et al, 2010). The kidney recipients were randomly assigned in this study into to one of two hydration regimens. The hydration regimens that used were either the constant infusion rate (CIR) regimen or the CVP target (CVPT) regimen. The CIR group received normal saline at a constant infusion rate of a range 10 to 12 ml.kg-1.-1h from the start of surgery until the renal vessels were unclamped at the end of anastomosis. Isotonic saline 0.9% was infused using a volumetric infusion pump. The CVPT group received normal saline at two different CVPT phases. The first "pre-ischemia" phase was from the start of surgery until the renal artery in the donor kidney was clamped. During this time, saline was infused slowly to maintain the CVP at target within 5 mmHg. In the second "ischemia" phase, from clamping the donor renal artery until unclamping of the recipient renal artery after vascular anastomosis completion, normal saline was infused to maintain a CVPT of around 15 mm Hg. Systolic, diastolic, mean arterial blood pressure, and CVP values were recorded 30 minutes after induction of anesthesia, at the time of renal artery clamping in the donor (onset of ischemia), at unclamping of the vessels after completion of the vascular anastomosis (end of ischemia), and at the end of surgery. Also renal ischemia time, concurrent saline infusion rate, time of onset of urine production on unclamping of the renal artery, and total urine output from unclamping of the renal vessels to the end of the surgery were recorded. Kidney turgidity was evaluated blindly by the surgical team members on a 3-point scale: score I (soft graft), score II (moderately turgid graft), and score III (highly turgid and firm graft).After surgery, all patients were assessed for the presence of tissue edema, especially in the conjunctiva, eyelids, face, and upper airway. Postoperative graft function was evaluated by estimation of fraction extraction sodium ratio (FENa %) after surgery to assess renal concentrating power: Daily serum creatinine, creatinine clearance, and total urine output were recorded for five days postoperatively. Patients in the CVPT group showed better intraoperative graft turgidity, arterial blood pressure stability, earlier diuresis, and rapid improvement of postoperative graft function. This was achieved in the CVPT group without an overall increase in infused saline volume (ranged 3 liters), vasopressor use, and diuretic doses compared with the CIR. The biphasic hydration regimen applied in the CVPT group with delayed most of the crystalloid administration until shortly before the renal vessels were unclamped (with a calculated range of 45-50 ml/min during ischemia time) had more favorable outcome.

Hypotension may occur after unclamping the renal vessels and reperfusion of the graft. It is important to maintain the blood pressure because renal function is critically dependent on adequate perfusion. The two main factors that may precipitate to immediate revascularization hypotension:

1. Sudden shift of 25% of cardiac output to the renal graft.
2. Release of vasodilator mediators accumulated during renal ischemia period.

It is critical that the patient is adequately hydrated throughout renal transplant surgery in preparation for reperfusion of the graft. Close monitoring of the CVP, and avoidance of deep level of anesthesia during this period can prevent hypotension. The use of vasopressors with α agonist action may comprise blood flow to the transplanted organ. Additional fluid may be required to maintain blood pressure and replace urine output. Furosemide can enhance urine output. Loop diuretics block the Na+/K+ channels in the thin ascending loop of Henle. This prevents reabsorption of electrolytes in this part of the nephron. The high osmolar fluid then prevents reabsorption of water in the distal tubule. A large volume of fluid with high electrolyte content is excreted. Mannitol is freely filtered in the glomerulus, but not reabsorbed. It causes osmotic expansion of urine volume. Loop diuretics and /or mannitol may be used to promote diuresis from the grafted kidney. Mannitol improves renal blood flow, acts as a free radical scavenger and reduces the incidence of impaired renal function immediately after transplant (Kasper et al, 2005).

Another study was previously done for pediatric kidney recepients used average introperative fluids 88 ml/kg with a wide range of 30-90 ml/kg which reflected a large range of preoperative hydration status of recipients. However, younger children received higher volume of fluids per kilogram than older one. Also this study indicated that there was no correlation between the amount of fluid given intraoperatively and the occurrence of postoperative oliguria or acute tubular necrosis. (Coupe et al 2005).However, the intraoperative fluid replacement during kidney transplantation should be carefully titrated to the needs and overload must be avoided to get ride the problems that may developed if the new graft is either delayed to function or failing.

5. The choice of recipient fluid therapy

The choice of a particular solution in a given clinical situation may be guided by an understanding of the solutions' properties, but there is still an ongoing debate on the relative merits of crystalloid and colloid solutions for kidney recipients .The intravenous administration of adequate volumes of fluid is associated with earlier onset of graft function, lower postoperative serum creatinine, higher postoperative creatinine clearance, reduced incidence of delayed graft function, and improved graft survival. Most anesthesiologists avoid potassium-containing fluids during renal transplantation with the belief that it may worsen hyperkalemia in case of impaired graft function. The administration of normal saline and normal saline-based fluids (5% albumin) is the standard of care for fluid management in patients undergoing renal transplant surgery. This policy is primarily based on avoidance of potassium-containing fluids that can contribute to intra-operative hyperkalemia. The recipient's blood is usually typed and screened preoperatively. However, blood loss is usually minimal during uncomplicated kidney transplantation. Also blood transfusion is unlikely practice for kidney recipients except in highly indicated cases because of high possibility of triggering the patient's immune system. The anesthesiologist should attempt to maintain a mean blood pressure range of 60 to 80 mm Hg, central venous

pressure (CVP) between 10 to 14 cm H20 and mean pulmonary artery pressure of 18 to 20 mm Hg. The estimated blood loss during the case is usually minimal (< 300 ml). In some cases, greater blood loss may require transfusion of packed red cells. Packed red cells should be cytomegalovirus (CMV) negative.

5.1 Crystalloids

Crystalloids solutions are usually preferred during kidney transplantation to correct fluid and electrolyte imbalance (Table 1). However in certain situation as in severe hypovolemia, colloids may be valuable. A great source of controversy and debate is the choice of intra-operative fluid during kidney transplantation. In a survey conducted in over 90% of renal transplant centers in USA, normal saline was used for hydration during kidney transplantation (O'Malley et al 2002). Many studies have shown that the use of normal saline leads to a major increase in serum potassium compared with Ringer's lactate, most likely due to associated hyperchloremic metabolic acidosis through an extra cellular shift of potassium (O'Malley et al, 2005; Khajavi et al, 2008).

	+Na mMole/l	Cl- mMole/l	K+ mMole/l	Ca++ mMole/l	Mg++ mMole/l	Additives (bicarbonate)
Normal Saline (0.9%)	154	154	-	-	-	-
Lactated Ringer's	130	109	4	1.5	-	Lactate(28)
Acetated Ringer's	130	109	4	1.5	-	Acetate(28)
Plasmalyte	140	98	5	1.5	3	Acetate (27) + Gluconate(23)

Table 1. Commonly used crystalloids and their composition:

Hyperchloremia may have adverse renal effects through vasoconstriction in afferent and efferent arteriolar beds of kidney and may result in a decrease in the urine output (Wilcox, 1983). Consequently, the use of Ringer's lactate is now preferred in renal transplant surgery. It is essential to acknowledge that intravenous fluids are behaved like drugs with indications, contraindications, and side effects. With this in mind, the anesthetist must carefully choose the type of fluid for intra-operative use during kidney transplantation .This choice is based on number of factors. These factors include the physical properties of the solution, the patient's biochemical profile with special reference of serum electrolytes and surgical circumstances.

The principal component of crystalloid fluids is the inorganic salt sodium chloride (NaCl). Sodium is the most abundant solute in the extracellular fluids, and it is distributed uniformly throughout the extracellular space. Because 75 to 80% of the extracellular fluids are located in the extravascular (interstitial) space, a similar proportion of the total body sodium is in the interstitial fluids. Exogenously administered sodium follows the same distribution, so 75 to 80% of the volume of sodium-based intravenous fluids are distributed in the interstitial space.This means that the predominant effect of volume resuscitation with crystalloid fluids is to expand the interstitial volume rather than the plasma volume. An infusion of 1 L of 0.9% sodium chloride (isotonic saline) adds 275 mL to the plasma volume and 825 mL to the interstitial volume. Note that the total volume expansion (1100 mL) is

slightly greater than the infused volume. This is the result of a fluid shift from the intracellular to extracellular space, which occurs because isotonic saline is actually hypertonic to the extracellular fluids.

5.1.1 Isotonic (normal)Saline

The prototype crystalloid fluid is 0.9% sodium chloride (NaCl), also called isotonic saline (osmolarity=308 mOsmole/l) or normal saline. The latter term is inappropriate because a one normal (1 N) NaCl solution contains 58 g NaCl per liter (the combined molecular weights of sodium and chloride), whereas isotonic (0.9%) NaCl contains only 9 g NaCl per liter. The pH of isotonic saline (pH=5.7)is also considerably lower than the plasma pH. These differences are rarely of any clinical significance. The chloride content of isotonic saline is particularly high relative to that of plasma (154 mEq/L versus 103 mEq/L, respectively), so hyperchloremic metabolic acidosis is a potential risk with large-volume isotonic saline infusion.

5.1.2 Lactated Ringer's

Ringer's solution was introduced in 1880 by Sydney Ringer, a British physician and research investigator who studied mechanisms of cardiac contraction. The solution was designed to promote the contraction of isolated frog hearts, and contained calcium and potassium in a sodium chloride diluent. In the 1930s, an American pediatrician named Alexis Hartmann proposed the addition of sodium lactate buffer to Ringer's solution for the treatment of metabolic acidoses. The lactated Ringer's solution, also known as Hartmann's solution, gradually gained in popularity and eventually replaced the standard Ringer's solution for routine intravenous therapy.

Lactated Ringer's solution contains potassium and calcium in concentrations that approximate the free (ionic) concentrations in plasma. The addition of these cations requires a reduction in sodium concentration for electrical neutrality, so lactated Ringer's solution has less sodium than isotonic saline. The addition of lactate (28 mEq/L) similarly requires a reduction in chloride concentration and has pH approximate 6.7. The chloride in lactated Ringer's is more closely approximates plasma chloride levels than does isotonic saline. Lactated Ringer's is also not an ideal crystalloid.The calcium in lactated Ringer's can bind to certain drugs and reduce their bioavailability and efficacy.Also,lactated Ringer's is considered a moderately hypotonic (Osmolarity=273 mOsmaole/l) crystalloid solution. So, many studies recommend limited use of lactated Ringer's in patients who at risk of cerebral edema (Feldman et al; 1995).

5.1.3 Acetated Ringer's

Acetated Ringer's isolution is similar in its compostion to lactated ringer's except replacement the lactate with acetate which could converted to bicarbonate in all body cells including muscles(Hahn &Drobin, 2003).

5.1.4 Plasmalyte (Normosl)

Plasmalyte is a balanced salt solution having electrolyte compostion and osmolarity (294 mOsmole/l) similar to that of plasma.The major feature of these solutions is the added buffer capacity, which gives them a pH that is equivalent to that of plasma (pH=7.4). Acetate and gluconate content act as precursors of bicarbonate. This converstion occur predominantly in the liver,although acetate could be converted to bicarbonate in other body

tissues resulting in less acidosis.An additional feature is the addition of magnesium, which may provide some benefit in light of the high incidence of magnesium depletion in hospitalized patients .A previous relevant study, which compared different crystalloid solutions on acid-base balance and early kidney functions after kidney transplantation,have concluded that plasmalyte has the best metabolic profile (Hadimioglu et al, 2008).

5.2 Colloids

Natural available colloid as human albumin has been widely applied for the treatment of hypovolemia in critically ill and surgical patients during the last two decades. Albumin is being widely replaced by many synthetic colloids such as dextrans, gelatins, and hetastarch (HES) solutions. Colloids are stayed in the intravascular compartment because of their macromolecules composition. The degree of plasma volume expansion exerted by colloids is determined by their concentration, molecular weight, chemical structure, colloid osmotic pressure, metabolism, and elimination rate. HES solutions have varying effects on coagulation characteristics, which depend on the size of the HES molecules and the degree of hydroxethyl substitution. Impaired platelet function, and impaired coagulation profile as measured by thromboelastography have been reported to arise during the administration of HES. This raises some concern for end stage renal patients undergoing kidney transplantation, because they are prone to bleeding complications because of associated platelet dysfunction (Boccardo et al; 2004**)**. Although it is rare, severe and life-threatening anaphylactic reactions have been reported in association with any of the commonly used semi-synthetic colloids and with albumin. The incidence of severe anaphylactic reactions is probably more frequent for gelatins (0.35%) and for dextrans (0.27%) than for albumin (0.10%) or for starches (0.06%) This required to be considered when weighing the risks/benefits for the use of different plasma volume expanders **(**Laxenaire et al ;1994). A study with a large series of renal transplants from deceased donors, revealed a statistically significant benefit from the usage of albumin, though mannitol, furosemide, and electrolyte solutions were administered concomitantly (Dawidson et al;1992). Protective properties to the intra-operative administration of mannitol during the vascular phase were attributed to the osmotic diuretic and the antioxidant properties of sugar alcohols substances. Two of the synthetic colloids that have widely replaced albumin in clinical practice – dextrans and gelatins – do not seem on the whole to be preferable to albumin. An old comparative study comparing intra-operative albumin and dextran-40 in renal transplant recipients from a living related donor did not show any significant difference between the two regimens with regards to urine volume output and serial serum creatinine concentrations after transplantation (Dawidson et al; 1987). The clinical value of this study may be limited, because small sample size (17 patients) had no enough statistical power to detect outcome differences. Dextran solutions have been associated with major side-effects, such as coagulation disorders, severe anaphylactic reaction, and acute tubular necrosis .This has led to major limitation for their usage as plasma volume expansion in kidney transplantation (Bergman et al; 1990).

Hetastarch (HES) solutions (table 2) are originally synthesized from natural polymers of amylopectin. The pharmacokinetics of HES solutions depend on their molecular weight and C2/C6 hydroxyethylation ratio which influences their degradation mainly by plasma amylase. Osmotic, nephrosis-like lesions were reported in 80% of transplanted kidneys after the use of routine volumes of HES 200/0.6 in brain-dead donors (Legendre et al ,1993) . The likely mechanism for this action may be swelling and vacuolization of the tubular cells, and

tubular obstruction due to hyper-viscous urine. Additionally, the slow degradation of high molecular weight or highly substituted HES may increase plasma osmotic pressure, leading to renal dysfunction and therefore these factors limit their use during kidney transplantation. The latest HES generation, HES 130/0.4, has a total body clearance about 23–31 times faster than that of the first generation hetastarch, and exhibits the best risk/benefit ratio of all available HES (Jungheinrich, and Neff ,2005).

	HES 70/0.5	HES 130/0.4	HES 200/0.5	HES 200/0.5	HES 200/0.62	HES 450/0.7
Concentration (%)	6	6	6	10	6	6
Volume efficacy (%)	100	100	100	130	100	100
Volume effect (hours)	1-2	2-3	3-4	3-4	5-6	5-6
Mean molecular weight (KD)	70	130	200	200	200	450
Molar substitution	0.5	0.4	0.5	0.5	0.62	0.7
C2/C6 ratio	4:1	9:1	6:1	6:1	9:1	4.6:1

Table 2. Characteristics of different available hydroxyethyl starch (HES) solutions.

HES preparations (table 2) are characterized by the following criteria:
(A) Concentration (6%, 10%),
(B) Molecular weight (Mw: the sum of each molecule's weight devided by the total mixture's weight times the weight of the molecule):

- Low-molecular weight [LMW]-HES: 70,000 dalton.
- Medium-molecular weight [MMW]-HES: 130,000 to 260,000 dalton.
- High-molecular weight [HMW]-HES: > 450,000 dalton,

(C) Molar substitution (MS: the molar ratio of the total number of hydroxyethyl groups to the total number of glucose units):

- Low MS: 0.4 and 0.5
- Moderate MS: 0.62
- High MS: 0.7

(D) C2/C6 ratio. The ratio of the C2:C6 hydroxyethylation appears to be key factors for pharmcokinetic behaviour of HES and possibly also for its side effects (e.g. accumulation).
However, there still some debates surrounding the effects of hetastarch solutions on renal function, especially in the field of kidney transplantation.
Over the last few decades, there has been a shift in anesthesia practice from using natural colloids such as blood, albumin and fresh frozen plasma to synthetic colloids .However, the widespread use of synthetic colloids during kidney transplantation is still need more investigations to confirm their safety.
The evidence for Targeted Fluid Administration suggests that administration of colloid provides benefits over crystalloids. However no head-to-head trials of crystalloid versus colloid or colloid versus colloid during kidney transplantation have been performed.

Likewise all the clinical trials of Targeted Fluid Administration used are saline-based fluids. A new controversy surrounds the adequate amount of peri-operative fluid administration. For decades the strategy has been to keep the patient normovolaemic ('well hydrated') in the perioperative period. Early urine production is important in kidney transplantation as a good prognostic factor. It is usually associated with longer graft survival and lower morbidity. Early diuresis is commonly observed in live donor grafts. In dead donor grafts, onset of diuresis is usually delayed due to the variable period of kidney ischemia and their storage at low temperatures in electrolyte solutions until they are implanted. Some measures, such as the administration of large volumes of liquids and diuretics, have been advocated to obtain good diuresis at the end of the surgery. Mannitol induces osmotic diuresis and also has a protective effect on the tubular cells of transplanted kidney from ishaemic injury. The renal protective agents as mannitol used during kidney transplantation seems to be related to its ability to increase renal blood flow. This presumably is due to the result of release of intrarenal vasodilator prostaglandin and atrial naturetic peptide. Also, loop diuretics as furosemide act by blocking the Na+/K+ ATPase channels present in the thin ascending limb of Henle, decreasing tubular oxygen consumption which may offer some protection against ischemic injury(Esson and Schrier;2002).

Hypotension may occur after unclamping the vessels and reperfusion of the graft. It is important that the patient should be well hydrated, as renal function is critically dependent on renal perfusion. It is especially important in paediatric recipients because reperfusion of an adult size graft may divert a significant amount of their own blood volume. A previous study for special fluid strategy in pediatric kidney transplantation, a total mean volume of 18 ml.kg-1.h-1was infused, which divided to include approximately 8 ml.kg-1.h-1 of crystalloid, 7 ml.kg-1.h-1 of fresh frozen plasma, and 2 ml.kg-1.h-1 of washed red blood cells(Yamamoto et al 2003).

Central venous pressure value may decrease around 50% within two hours after revascularization despite aggressive fluid management. This decline is similar in recipients of both cadaveric and living related kidney donor and the cause may be multi-factorial such as redistribution of fluids, changes in vascular permeability or increased nitric oxide levels. The use of vaso-pressors ,with alpha agonist activity, are better to be avoided as they can compromise blood flow to the transplanted kidney. Loop diuretics, and mannitol may be used to enhance urine production. Low dose dopamine was previously used to stimulate dopaminergic receptors (DA1) in the kidney vasculature to induce vasodilatation and increased urine output. However, the utility of this approach is questioned in a denervated kidney, which it may not respond adequately to a low dose of dopamine as normal kidneys do.

6. Monitoring

Standard ASA monitors are adequate, although, patients with more advanced co-morbid conditions require more extensive monitoring such as continuous arterial blood pressure and pulmonary artery monitoring. Routine monitors include noninvasive arterial blood pressure, ECG, core temperature, end-tidal carbon dioxide ($ETco_2$), and arterial oxygen saturation SpO_2. CVP monitoring is required for all patients in order to guide volume management and for postoperative vascular access. .Arterial monitoring is reserved for small children undergoing anastamosis of the allograft to the great vessels. Older children undergoing anastamosis to the iliac vessels do not require arterial monitoring, and in fact it should be avoided in order to preserve sites for future arteriovenous fistulae. Swan-Ganz

monitoring of pulmonary artery pressures may be necessary in the infrequent patients with symptomatic hypertensive cardiomyopathy or with symptomatic cardiac dysfunction. All patients have urinary catheters inserted prior to surgery for urine output records. Laboratory investigations every 1-2 hours to follow blood hemoglobin ,Hct, serum K+ and acid-base status. Those with the severe co-morbid conditions, such as symptomatic coronary artery diseases or history of congestive heart failure, should be monitored with a non-invasive transesophageal echocardiography to monitor cardiac functions.

7. Postoperative recipient fluid therapy

Strict monitoring of fluid input and urine output is essential especially in the early postoperative period to guide the function of the new graft. A study showed that recipients of living donor kidneys lost more serum albumin during surgery than their donors, resulting in decreased plasma volume that was associated with reduced post-operative urine output. Therefore, it was recommended that administration of postoperative colloids administration is necessary to replace the additional loss of albumin during transplant surgery (Dawidson et al; 1987). On the first day after successful transplantation, serum creatinine concentration is usually related to mean arterial blood pressure. It is decreased in patients with mean arterial pressure (MAP) above 100 mmHg, whereas it remained stable in patients with MAP of 80–100 mmHg and increased in patients with MAP below 80 mmHg (Toth et al ;1998). Post operative daily graft function was evaluated in another recent study that compared the CVP target regimen(15 mmHg) with constant infusion regimen(10-12 ml.kg-1.hour-1) during transplantation (Othman et al; 2010) .It was based on the renal concentrating ability, as reflected by the fractional excretion of sodium (FENa%) for 6 hours in immediate postoperative time. Also, serum creatinine level, creatinine clearance, and urine output were monitored daily for 5 days after surgery. This study reflected early postoperative faster decrease of serum creatinine with higher creatinine clearance and larger urine output in the CVP target group .This finding could attest to the sustained benefit of the central venous pressure titration approach over the constant infusion approach. .FENa % may be affected by a high diuretic dose that acts by altering the handling of sodium by the kidney. In this study, all patients in the constant infusion regimen group and only 50% of patients in the CVPT group had received variable large doses of furosemide, which might account for the early decrease of FENa %. Therefore, FENa % may be not useful as a renal function test for comparison between the used hydration regimens (Othman et al ; 2010).

Maintenance of crystalloid hydration during postoperative period must be adjusted accordingly to vital signs and urine output. Replace urine output (ml per ml) with crystalloid selected according to graft function and patient serum electrolytes. A rigorous postoperative intravenous hydration protocol in renal transplant recipients may protect against vascular thrombosis. Delayed graft function is mainly defined as the need for dialysis in the first week after transplant. It may result from a collection of various detrimental factors such as recipient's age, tissue match and any surgical complications as vessel thrombosis or bleeding. One-year graft survival of a first transplant is approximately 95%; for recipients of non-identical living-related kidneys, it approximates to 90%; for recipients of cadaver kidneys, it approximates 80%; and for re-transplanted recipients of cadaver kidneys, it is usually less to approximate 70%. Overall, recipient survival of approximately 95% during the first post-transplant year can be expected, although cardiovascular deaths remains a major concern (Flechner ; 1994).

Postoperative fluid management plan for kidney transplantation should be judicious and be modified in favor of maintaining just adequate filling pressures to maintain adequate intravascular volume and baseline hemodynamics .Additional fluids as per need once urine output from the new graft starts to decline guided by CVP and myocardial function and avoid overload that may empress the heart function with the recommendation of dialysis in presence of delayed graft function or acute tubular necrosis.

8. Summary

Graft viability associated with renal transplantation is a product of the proper managing of the kidney donor, the allograft, and the recipient patient. Short- and long-term outcome is influenced by perioperative fluid policy. The function of the transplanted kidney seems to be optimized if graft perfusion is greatly maximized through good hydration policy with CVP target to approximate15 mmHg. A strategy of crystalloid administration to a target central venous pressure resulted in better stability of intraoperative blood pressure, less use of vasopressors and furosemide. This could induce a faster decrease in serum creatinine towards normal vlue. Perioperative close monitoring of recipients and optimization of intravascular fluid volume status to maximize graft perfusion are the usual keys for long-term success of renal transplants. Crystalloids are usually considered as the first choice and some colloids could be used safely as alternatives during the procedure and in early postoperative periods. The ideal crystalloid solution seems resemble the plasma composition with special reference to electrolyte content .Although, lactated and acetated Ringer's solutions are moderately hypo-osmolar, isotonic normal saline has high chloride content that could induce hyperchloermic acidosis. Both lactate and acetate are considered as precursors of bicarbonate where lactate converted to bicarbonate in the liver and acetate converted to bicarbonate in all body tissues resulting in less acidosis. A mixture of normal saline with either lactated or acetated Ringer's solution may be the preferred crystalloid choice of fluid therapy during kidney transplantation. This policy could provide better guidance for perioperative hydration strategy during kidney transplantation until best evidence and multi-center guidelines will be established based upon more research in this field.

9. References

Baxi V, Jain A, Dasgupta D. Anesthesia for renal transplantation: An update. Indian J Anaesth. 2009 Apr;53(2):139-47.

Bergman A, Andreen M, Blomback M. Plasma substitution with 3% dextran-60 in orthopaedic surgery: influence on plasma colloid osmotic pressure, coagulation parameters, immunoglobulines and other plasma constituents. Acta Anaesthesiol Scand 1990; 34 : 21-29.

Boccardo P, Remuzzi G, Galbusera M. Platelet dysfunction in renal failure. Semin Thromb Hemost 2004; 30(5):579-589.

Carlier M, Squiifflet JP, Prison Y, et al. Maximal hydration during anesthesia increase pulmonary arterial pressure and improve early function of human renal transplants. Transplantation 1982;34: 201-204.

Coupe N,O'Brien M, Gibson P et al. Anesthesia for pediatric renal transplantation with and without epidural analgesia- a review of 7 years experience. Paediatr Anaesth 2005;15;220-228.

Dawidson I, Berglin E, Brynger H, Reisch J. Intravascular volumes and colloid dynamics in relation to fluid management in living related kidney donors and recipients. Crit Care Med 1987; 15: 631– 636.

Dawidson IJ, Sandor ZF, Coorpender L, et al. Intraoperative albumin administration affects the outcome of cadaver renal transplantation. Transplantation 1992; 53(4): 774-782.

Esson ML,Schrier RW .Diagnosis and treatment of acute tubular necrosis. Ann Inten Med 2002; 137:744-752.

Feldman Z,Zachari S, Reichementhal E, et al. Brain edema and neurological status with rapid infusion of lactated ringer's or 5%dextrose solution following head trauma. J Neurosurg 1995;83:1060-1066.

Ferris RL, Kittur DS, Wilasrusmee C, et al. Early hemodynamic changes after renal transplantation: determinants of low central venous pressure in the recipients and correlation with acute renal dysfunction. Med Sci Manit 2003; 9(2):CR61-CR66.

Flechner SM: Current status on renal transplantation. Urol Clin North Am 1994; 21: 265–282.

Hadimioglu N, Saadawy I, Saglam T et al. The effect of different crystalloid solutions on acid-base balanca and early kidney function after kidney transplantation. Anesth Analg 2008;107: 264-269.

Hahn RG and Drobin D. Rapid water and slow sodium excretion of acetated Ringer's solution dehydrates cells. Anesth Analg 2003; 97:1590-1594.

Jungheinrich C, Neff TA .Pharmacokinetics of hydroxyethyl starch. Clin Pharmacokinet 2005; 44: 681-699.

Kasper DL, Braunwald E, Fauci AS. Harrison's principles of internal medecine, 16th ed. New York: McGraw-Hill, 2005 ;1645.

Khajavi MR, Etezadi F, Moharari RS. Effects of normal saline vs.lactated Ringer's during renal transplantation. Renal Failure 2008;30 :535-539.

Laxenaire MC, Charpentier C, Feldman L. Anaphylactoid reactions to colloid plasma substitutes: incidence, risk factors, mechanism. A French multicenter prospective study. Ann Fr Anesth Reanim 1994;13: 301-310.

Legendre C, Thervet E, Page B, et al .Hydroxyethylstarch and osmotic-nephrosis-like lesions in kidney transplantation. Lancet 1993; 342: 248-249.

O'Malley CMN, Frument RJ, Bennett EG. Intravenous fluid therapy in renal transplant recipients: results of a US survey. Transplant Proc 2002; 34:3142-3145.

O'Malley CMN, Frumento RJ, Hardy MA, et al. A randomized double blind comparison of lactated Ringer 's solution and 0.9%Nacl during renal transplantation .Anesth Analg 2005;100:1518-24.

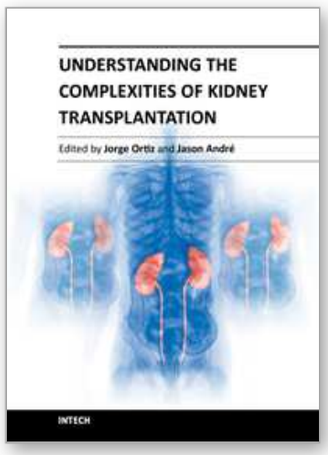
Othman MM, Ismael AZ, Hammouda GE.Impact of timing of maximal crystalloid hydration on early graft functions during kidney transplantation. Anesth Analg 2010; 110 (5): 1440-1446.

Schnuelle P and Johannes Van der Woude F. Perioperative fluid management in renal transplantation: a narrative of the literature. Transplant int ,2006 ;19: 947-959.

Toth M, Reti V, Gondos T. Effect of recipients' peri-operative parameters on the outcome of kidney transplantation. Clin Transplant1998; 12: 511–517.

Wicox CS. Regulation of renal blood flow by plasma chloride. J Clin Invest 1983; 71:726-735.

Yamamoto R, Nakai R, Nagasawa M et al. Anesthetic management of pediatric renal transplantation: A review of 15 cases under age of 10 years. Masui. 2003 52(6):631-635.



Understanding the Complexities of Kidney Transplantation
Edited by Prof. Jorge Ortiz

ISBN 978-953-307-819-9
Hard cover, 564 pages
Publisher InTech
Published online 06, September, 2011
Published in print edition September, 2011

Kidney transplantation is a complex field that incorporates several different specialties to manage the transplant patient. This book was created because of the importance of kidney transplantation. This volume focuses on the complexities of the transplant patient. In particular, there is a focus on the comorbidities and special considerations for a transplant patient and how they affect kidney transplant outcomes. Contributors to this book are from all over the world and are experts in their individual fields. They were all individually approached to add a chapter to this book and with their efforts this book was formed. Understanding the Complexities of Kidney Transplantation gives the reader an excellent foundation to build upon to truly understand kidney transplantation.

IntechOpen