Pediatric Kidney Transplantation: Peri/Post-Operative Management

INTRODUCTION

There are two broad goals of fluid management and assessment in the Pediatric Transplant Patient: the transplanted kidney needs to receive adequate perfusion and make adequate amounts of urine.

FLUIDS

Post-operative "optimal" fluid treatment following pediatric kidney transplantation is critical.

- Evidence shows that fluid management to maintain cardiac output and optimize kidney perfusion, improves outcomes post-transplant.
- Frequent clinical assessment of the transplant recipient's fluid status is important to ensure adequate fluid replacement.
- Traditional parameters and clinical assessment of fluid status may be unreliable due to compromised homeostatic mechanisms and the *post-ischemic* transplanted kidney.

Management of post-operative fluids in pediatric kidney transplant patients includes:

i. Insensible fluids + ml per ml urine output replacements:
   - initially replace with IV fluids every q30min then q1h
   - may require replacement more frequently if polyuria >10ml/kg/h

ii. Generally, start D5% 0.9%NS for insensibles and Plasmalyte (or 0.9%NS) for replacements (higher rate)
   - reassess fluids according to clinical status and bloodwork (Na, Cl, etc); monitor for hypernatremia and hyperchloremia

iii. Use fluid boluses prn as indicated

Fluid Bolus: Positive Net Fluid Gain

To maintain transplant kidney perfusion, adequate intravascular volume is required.

- Volume resuscitation is needed to replace distributive intravascular fluid losses due to capillary leak.
- Mild edema is common and expected in the first several days post-transplant
- Severe fluid overload should be avoided.

- Determination of volume status requires BOTH physical examination and estimation of perfusion.
- Bolus (eg. 5 -10 mL/kg over 15-20 min) with isotonic solutions to correct volume depletion.
- Volume status should be re-assessed after each bolus.
- Fluid boluses repeated only as needed based on clinical assessment.
- A bolus should be recorded as "positive net fluid gain" that should NOT be accounted for in the calculation of hourly urinary losses replacement.
- The need for > 3 fluid boluses should prompt review of the clinical status and treatment targets by both Nephrology and PICU teams (ie. discussions, or bedside rounds as needed).

** Prior to transfusion of pRBC's, review with nephrology as this is a risk for HLA sensitization.**

Indicators of INSUFFICIENT kidney allograft perfusion may include:

- o Poor perfusion on physical examination
- o Low blood pressure and narrow pulse pressure (low if < 25% of the systolic value)
- o Tachycardia (not related to pain or agitation)
- o Decreasing urine output
  - Urea/creatinine ratio and FENa are **NOT** good indicators of kidney perfusion immediately post-transplant and are unlikely to provide useful information to guide volume resuscitation.

Indicators of SUFFICIENT kidney allograft perfusion may include:

- ○ Steadily improving serum creatinine IS a good sign of adequate kidney perfusion.
- ○ Good urine output is a helpful indicator BUT ** will be <u>less reliable</u> if the patient has native kidney residual urine output**
- ○ Ultrasound is a useful investigation to assess perfusion of the allograft and to check for evidence vascular complications.

Blood Pressure Targets

Adequate blood pressure management can improve kidney perfusion and reduce the risk of delayed graft function.

- Most donor kidneys are adult size and are adapted to a normal *adult* blood pressure to maintain adequate perfusion.
- Therefore, early post-op, we aim for DONOR blood pressure if available.
- Otherwise, we base our BP target on age, size, and recipient pre-transplant blood pressure; usually above the 95th% BP.
- In young children, this may result in the use of inotropes early on (see below section on inotropes).

Mean Arterial Pressure (MAP)

MAP is the average arterial pressure throughout one cardiac cycle, systole, and diastole.
MAP is considered a better indicator of perfusion to vital organs than systolic blood pressure.

- MAP is targeted to the 95th%ile for age after kidney transplant.
- Maintaining the target MAP may require a combination of both fluids and inotropes.
- See table at end of document for MAP values in children.

Central Venous Pressure (CVP) monitoring

CVP is a measure of right atrial pressure, so may be an indicator of cardiac pre-load but is also greatly impacted by cardiac function (including valvular insufficiency, or ventricular dysfunction) and intrathoracic pressure (eg. positive pressure ventilation).

- CVP should NOT be used to interpret volume status *in isolation* of other markers of adequate kidney perfusion.
- CVP may NOT be used as an indicator in every patient
- CVP is usually targeted to 8-10 cm H_2O, recognizing that every patient is different, and some may have adequate circulating blood volume and cardiac output at a lower CVP.
- High CVP (>8 cm H2O after confirming transducer level) may argue against the need for ongoing volume support (or reflect another cardiac or intrathoracic pathology), but a fluid challenge might still be warranted in the patient.
    - For example, if the CVP is 8, if there is no change following a small fluid bolus, this might indicate the need for a further fluid bolus.
    - Alternatively, if the CVP increases after a small fluid bolus, BP support may require titrating an inotrope or vasopressor. And in this case, a cardiac echo to assess cardiac function might be considered.

Inotropes

Adequate blood pressure, in the high range for the recipient, (if BP of the donor unknown) is desired to maintain good kidney allograft perfusion.

- Adult-sized *donor* kidneys in smaller recipients require significantly increased cardiac output to maintain adequate kidney perfusion, which may be difficult for the recipient to achieve without initial inotropic support.
- Recipients who are clinically euvolemic on assessment but have insufficient blood pressure to maintain kidney perfusion may benefit from inotropic support. This is usually *not* required beyond the first 24-48 hours post-operatively.
- Prior to considering inotropic support, confirm that adequate intravascular volume status based upon clinical exam and MAP (or CVP) at target range.
- Consider adding inotropic medication infusion (eg. norepinephrine, dopamine) if low kidney perfusion is suspected based on urine output or change in serum creatinine.
    - Selection of most appropriate inotropic medication should be discussed between PICU and Nephrology teams.
- Consider adding an inotrope if MAP < set target (95^{th}%ile for age).

ANTICOAGULATION

Vascular thrombosis is a well-described and devastating complication of kidney transplantation.

- Usually, nephrology will use prophylaxis, **heparin 10 units/kg/hour**, in those <20-25kg or if concerns about difficult surgical anastomosis (small and/or multiple vessels).
- Anticoagulation may be discontinued after about 3-7 days usually and ONLY if the recipient is considered 'euvolemia' post-transplant.
- If THROMBOPHILIA concerns or a diagnosis such as Factor V Leiden, etc then therapeutic heparin 20 units/kg/hour aiming for therapeutic range based on standard heparin assay & Hematology recommendation; discontinuation or change in therapy only after discussion with Hematology.

ULTRASOUND / RADIOLOGY MONITORING

Ultrasound is a principal imaging test in kidney transplants and is used to evaluate for treatable surgical complications and/or thrombosis early following transplantation.

- **Early post-op ultrasound** after vascular anastomosis SHOULD be performed, especially in younger recipients; usually just after arrival to PICU.
- In addition to above, a ROUTINE ultrasound in the first 24-hours should be completed; usually the next day if first ultrasound shows no concerns.
- Additional ultrasound prn as indicated.
- A Mag3 Renal Scan is usually performed at Day 2-3 to ensure adequate perfusion to the entire kidney; please discuss timing with Nephrology as earlier testing may be indicated.

REFERENCES

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APPENDIX

Appendix 1: Calculated mean arterial pressure (MAP) in children (1)

Table 3. Calculated mean arterial blood pressure (mm Hg) according to height percentiles among boys (M) and girls (F) 1–18 yrs old

		Mean Arterial Blood Pressure for Boys and Girls, Percentile for Height									
		5th		25th		50th		75th		95th	
Age, Yrs	Percentile for Blood Pressure	M	F	M	F	M	F	M	F	M	F
1	5	30	35	33	37	34	37	36	39	37	40
	50	49	53	52	54	53	55	54	57	56	58
	95	69	71	70	72	72	73	73	74	74	76
2	5	35	39	38	41	39	42	40	42	41	44
	50	54	57	56	58	57	59	59	60	60	62
	95	73	75	75	76	76	77	77	78	79	80
3	5	39	42	41	44	42	44	44	46	45	47
	50	58	60	60	61	61	62	62	64	64	65
	95	77	78	78	79	80	80	81	81	82	83
4	5	42	45	43	46	46	47	47	47	48	49
	50	61	63	63	64	64	65	66	65	67	67
	95	79	80	82	82	83	83	84	84	86	85
5	5	45	46	47	48	49	49	49	50	51	52
	50	63	64	66	66	67	67	68	68	69	69
	95	82	82	84	83	85	85	87	86	88	87
6	5	47	49	49	50	50	51	52	52	53	54
	50	66	66	67	68	69	69	70	69	71	71
	95	84	84	86	85	87	86	88	87	90	89
7	5	51	50	50	51	52	52	53	53	54	55
	50	67	68	69	69	70	70	72	71	73	72
	95	83	85	88	87	89	88	90	89	92	90
8	5	50	52	53	52	54	54	55	55	56	56
	50	69	70	71	70	72	71	73	72	75	74
	95	87	87	89	88	91	89	92	90	93	91
9	5	51	53	53	54	55	55	56	56	58	57
	50	70	71	72	71	73	73	75	74	76	75
	95	88	89	91	89	92	90	93	91	94	93
10	5	52	54	55	55	56	56	56	57	59	59
	50	71	72	73	73	75	74	75	75	77	76
	95	90	90	92	90	93	92	94	93	96	94
11	5	54	55	56	56	57	57	58	59	59	60
	50	72	73	74	74	75	75	76	76	78	78
	95	91	91	92	92	94	93	95	94	96	95
12	5	54	57	57	58	58	58	60	60	61	61
	50	73	75	75	75	77	76	78	78	79	79
	95	92	92	94	93	95	94	96	95	98	97
13	5	56	58	57	59	59	60	60	61	61	62
	50	75	76	76	77	77	78	79	79	80	80
	95	93	94	95	94	96	95	97	97	99	98
14	5	59	60	59	60	61	61	62	62	63	64
	50	75	77	78	78	79	79	80	80	82	81
	95	91	95	96	96	97	97	99	98	100	99
15	5	58	61	61	61	62	62	63	63	64	64
	50	77	78	79	79	80	80	82	81	83	82
	95	96	96	98	97	99	98	100	99	102	100
16	5	60	61	62	62	63	63	65	63	66	66
	50	79	79	81	80	82	81	83	82	85	84
	95	98	96	99	98	101	99	102	100	104	101
17	5	63	61	63	62	65	63	67	65	69	66
	50	81	79	83	80	84	81	85	82	87	84
	95	100	96	102	98	103	99	104	100	106	101

From Haque & Zaritsky, *Pediatric Critical Care Med* 2007