



University of California
San Francisco



Practice Variations in Intraoperative Fluid Therapy during Kidney Transplantation A Multicenter Analysis.

Dieter Adelman, Rania Elkhateb, Jamie Yang, David Chen, Kerstin Kolodzie, Sachin Kheterpal, Matthieu M Legrand, Nicholas Douville

Dieter Adelman, MD, PhD
MPOG 2024 Outcome Research Fellows
University of California, San Francisco

Adelman | MPOG Emerging Scholars | MPOG Retreat 2025





Disclosures | Conflict of Interest:

Haemonetics Corporation

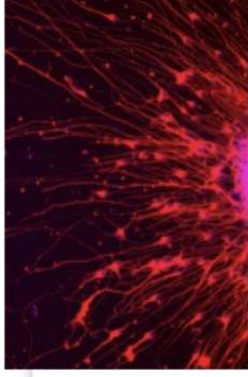
- Reimbursement for participation in a clinical trial (completed)
- Speaker honoraria (ongoing)
- not related to the content of this presentation

Anesthesia Subspecialties:



Adult Cardiac

UCSF anesthesiologists provide comprehensive care from routine cardiac surgery to complex procedures using advanced tech and leading research.



Neuroanesthesia

As one of the premier neuroanesthesia groups in the country we treat conditions including seizures, tumors, stroke, pain disorders and cerebrovascular pathologies.

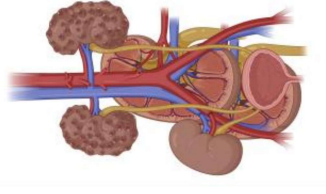


Liver Transplant

We provide outstanding clinical care to transplant patients at one of the largest and most successful liver transplant programs in the country.

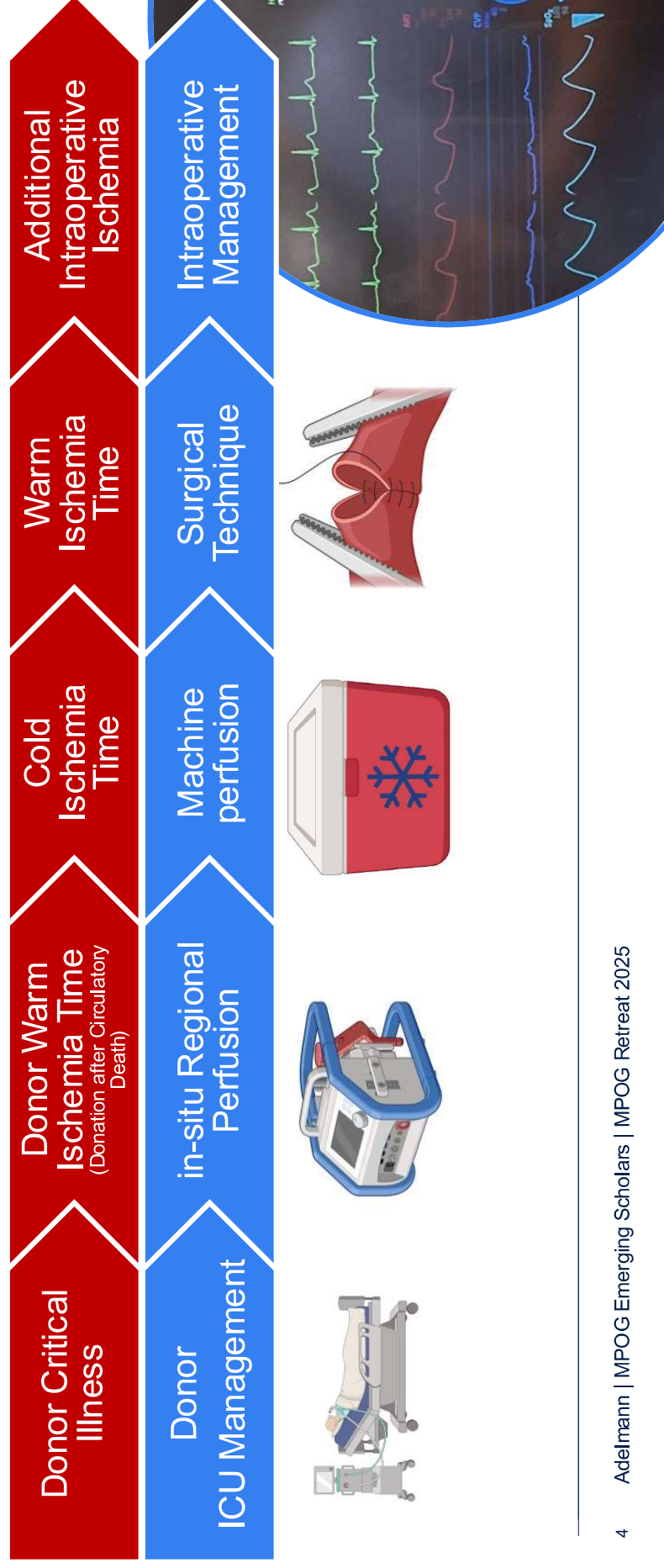


Kidney Transplant neglected or overlooked(?)



Background

The kidney is **vulnerable to ischemic injury** from organ donation through the intraoperative period and beyond.



Acute Kidney Injury of the Graft **Delayed Graft Function (DGF)**

**clinical manifestation of ischemia-reperfusion injury in the transplanted kidney
need for dialysis within seven days of transplant.**

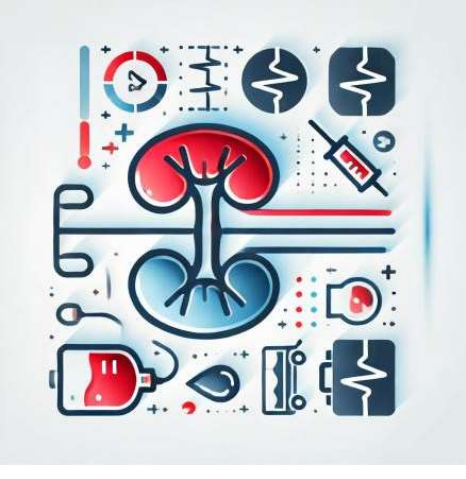
**dose-dependent effect between DGF duration
and graft loss**



Delayed Graft Function

most risk factors cannot be modified:

- Donor- and Recipient Comorbidities
- Cold and Warm Ischemia Time (logistics & surgical techniques)
- Organ Preservation (Machine Perfusion is protective)



Intraoperative care presents an opportunity to minimize additional ischemic injury to the graft.

Targets for Intraoperative Management



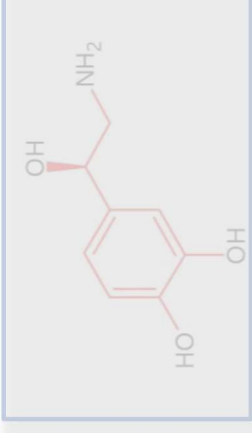
Fluids

To use the right type and the right amount of fluids



Blood Pressure

Maintain adequate renal perfusion pressure.



Vasopressors

Maintain perfusion pressure without impairing glomerular microcirculation.

Fluid Therapy



Normal saline was historically the preferred fluid during kidney transplantation

- lacks potassium, reducing concerns about hyperkalemia

however, it causes hyperchloremic metabolic acidosis can contribute to hyperkalemia

Intraoperative Fluid Therapy

Current Evidence – 2023: Randomized controlled Trial.

THE LANCET

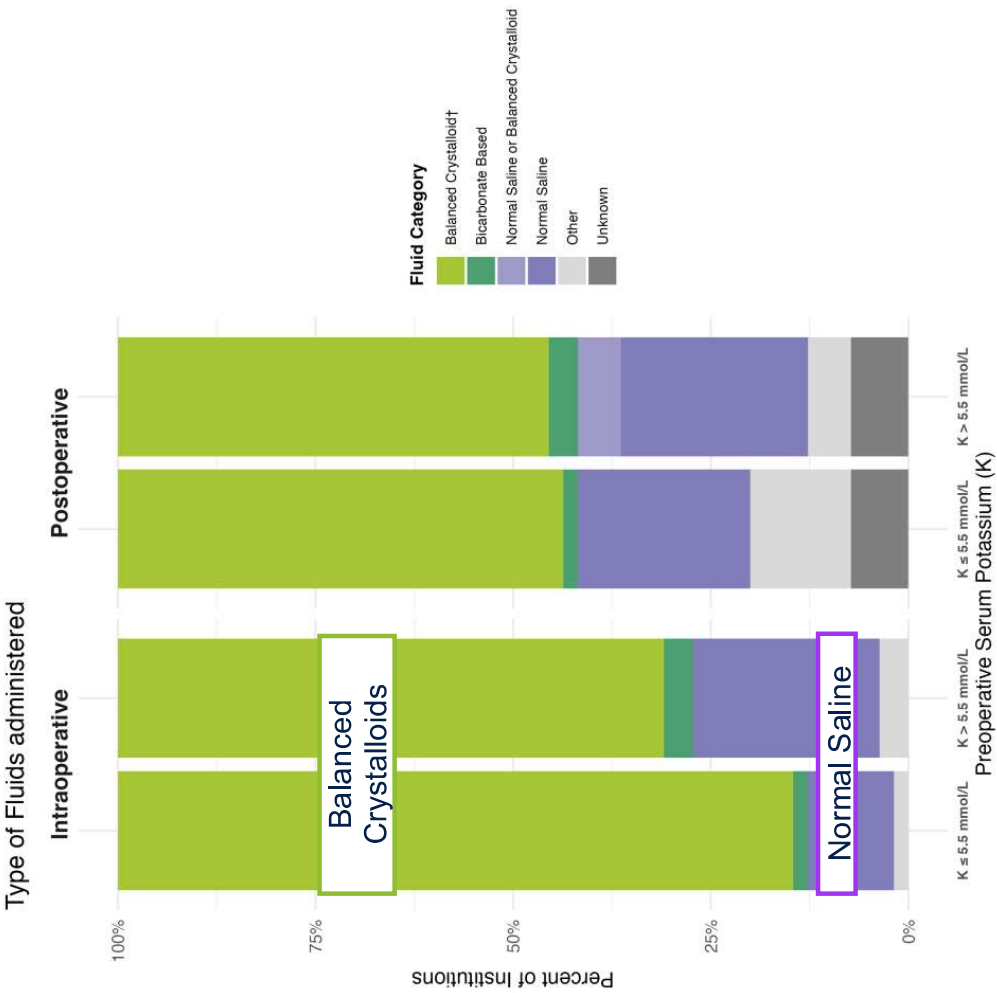


Balanced crystalloid solution versus saline in deceased donor kidney transplantation (BEST-Fluids): a pragmatic, double-blind, randomised, controlled trial

Patients: 808 Kidney Transplant Recipients, randomized to receive ...

Intervention: **intravenous balanced crystalloid solution** (Plasma-Lyte 148) or saline during surgery and up until 48 h after transplantation.

Outcome: **Reduced incidence of DGF in the balanced crystalloid group.** (adjusted risk difference 10·1% [95% CI 3·5 to 16·6])



But how does this translate to current care?

2025 Survey – 55 US Institutions

Which fluid do you use intraoperatively during Kidney Transplantation

Practice Variations in Intraoperative Fluid Therapy during Kidney Transplantation.

Patient level data:

19,165 Kidney Transplants
33 US Institutions
2018 - 2023

Outcome:

$$\frac{\text{intraoperative Balanced Crystallloid (ml)}}{\text{intraoperative Total Crystallloid (ml)}}$$

Ratio 1: Patient received Balanced Crystalloids only

Ratio 0: Patient received Normal Saline only

Practice Variations in Intraoperative Fluid Therapy during Kidney Transplantation.

The primary aim was to quantify the intraoperative use of balanced crystalloids — expressed as their percentage of the total crystalloid volume per case — and to assess the contribution of institution-, clinician-, and patient-level factors to variation in practice.

Outcome:

$$\frac{\text{intraoperative Balanced Crystalloid (ml)}}{\text{intraoperative Total Crystalloid (ml)}}$$

Ratio 1: Patient received Balanced Crystalloids only

Ratio 0: Patient received Normal Saline only

Updated Phenotype: Total Crystalloid Administered

Return Columns

Name	Data Type
CrystalloidsBalanced	Number
CrystalloidsNonQualifyHypertonic	Number
CrystalloidsNonQualifyHypotonic	Number
CrystalloidsNonQualifyOther	Number
CrystalloidsNormalSaline	Number
Crystalloids	Number

Updated Phenotype: Total Crystalloid Administered

A	B	C	D	E	F	G	H	I	J	K	L	M	N
MPOG Concept ID	MPOG Concept Name	Classification	Neutral-check	Anions	Cations	Tonicity-mOsmol/L	Sodium-mEq	Chloride-mEq	Potassium-mEq	Ca	Na	K	Mg
10456	LACTATED RINGERS	Balanced Crystalloid						130	109	4			
10461	DEXTROSE / LACTATED RINGERS 5%	Balanced Crystalloid						130	109	4			
10539	DEXTROSE 10% W/LR	Balanced Crystalloid						130	109	4			
10610	PLASMA-LYTE A (PH BALANCED)	Balanced Crystalloid						140	98	5			
10259	ELECTROLYTE-A SOLUTION	Balanced Crystalloid						140	98	5			
10457	NORMOSOL	Balanced Crystalloid						140	98	5			
10548	PLASMA-LYTE 148 W/DEXTROSE 5%	Balanced Crystalloid						140	98	5			
10406	SALINE 3%	Non-Qualifying – Hypertonic	0	513	513	1027		513	513	0			
10607	SALINE 2%	Non-Qualifying – Hypertonic						342	342				
10551	SALINE W/NAHCO3 0.45% + 150 MEQ/L	Non-Qualifying – Hypertonic											
10463	SALINE W/KCL 0.45% + 20 MEQ/L	Non-Qualifying – Hypotonic						143	124				
10559	DEXTROSE / SALINE W/KCL 5% / 0.45% + 40 MEQ/L	Non-Qualifying – Hypotonic						77	117	40			
10468	DEXTROSE / SALINE W/KCL 5% / 0.45% + 20 MEQ/L	Non-Qualifying – Hypotonic						77	97	20			
10594	DEXTROSE / SALINE W/KCL 5% / 0.45% + 10 MEQ/L	Non-Qualifying – Hypotonic						77	87	10			
10466	DEXTROSE / SALINE 5% / 0.45%	Non-Qualifying – Hypotonic						77	77				
10455	SALINE 0.45%	Non-Qualifying – Hypotonic						77	77				
10470	DEXTROSE / SALINE 10% / 0.45%	Non-Qualifying – Hypotonic						77	77				
10588	DEXTROSE / SALINE W/KCL 10% / 0.225% + 20 MEQ/L	Non-Qualifying – Hypotonic						38.5	58.5	20			
10549	PLASMA-LYTE 56	Non-Qualifying – Hypotonic						40	40	13			
10602	DEXTROSE / SALINE 10% / 0.225%	Non-Qualifying – Hypotonic						38.5	38.5				
10465	DEXTROSE / SALINE 5% / 0.225%	Non-Qualifying – Hypotonic						38.5	38.5				
10460	DEXTROSE / WATER 5%	Non-Qualifying – Hypotonic						0	0	0			
10462	DEXTROSE / WATER 10%	Non-Qualifying – Hypotonic						0	0	0			
10606	SALINE W/KCL 0.9% + 40 MEQ/L	Non-Qualifying – Other/unspecified						154	194	40			
10464	SALINE W/KCL 0.9% + 20 MEQ/L	Non-Qualifying – Other/unspecified						154	174	20			
10469	DEXTROSE / SALINE W/KCL 5% / 0.9% + 20 MEQ/L	Non-Qualifying – Other/unspecified						154	174	20			
10454	SALINE 0.9%	Normal Saline				308		154	154				
10467	DEXTROSE / SALINE 5% / 0.9%	Normal Saline				308		154	154				

Practice Variations in Intraoperative Fluid Therapy during Kidney Transplantation.

Adult Kidney Transplants

27,686 Cases

January 1st, 2018 – December 31st, 2023

-3,540 : Combined Transplants (Heart, Liver, Lung, Pancreas)

-37 : Kidney Transplants in Center-Years with ≤10 Cases

-19 : Erroneous Procedure Start or Stop Documentation

-3,555 : Missing Procedure Start or Stop Documentation

-29 : Blood Loss ≥ 2,000ml or Transfusion of ≥ 4 units

-326 : No Crystalloid Administration Documented

-953 : Crystalloid Outliers

-62 : Second Kidney Transplant in the Cohort

Final Cohort

19,165 Cases, 33 Institutions

Adelmann | MPOG Emerging Scholars | MPOG Retreat 2025

```
removing = nrow(data[proctypetxplung != "yes",])
remaining = nrow(data[proctypetxplung == "yes",])

##### Liver Transplant #####
liver_cases <- data %>%
  filter(grepl("liver", proceduretext, ignore.case = TRUE)) %>%
  select(wpocaseid, proceduretext)

data$proctypetxpliver[data$wpocaseid %in% liver_cases$wpocaseid] <- "yes"

count(data, proctypetxpliver)

cohort_description %>% add_row(description = "Liver Transplant",
  start = nrow(data),
  removing = nrow(data[proctypetxpliver != "yes",])
  remaining = nrow(data[proctypetxpliver == "yes",])

rm(liver_cases)

data %>% filter(proctypetxpliver != "yes")

##### Lung Transplant #####
lung_cases <- data %>%
  filter(grepl("lung", proceduretext, ignore.case = TRUE)) %>%
  select(wpocaseid, proceduretext)

data$proctypetxplung[data$wpocaseid %in% lung_cases$wpocaseid] <- "yes"

count(data, proctypetxplung)

cohort_description %>% add_row(description = "Lung Transplant",
  start = nrow(data),
  removing = nrow(data[proctypetxplung != "yes",])
  remaining = nrow(data[proctypetxplung == "yes",])

rm(lung_cases)

data %>% filter(proctypetxplung != "yes")

##### Pancreas Transplant #####
pancreas_cases <- data %>%
  filter(grepl("pancreas|pancreat", proceduretext, ignore.case = TRUE))
  select(wpocaseid, proceduretext)

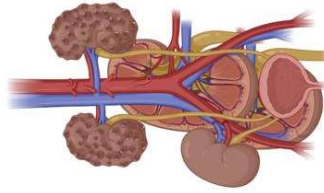
cohort_description %>% add_row(description = "pancreas Transplant",
  start = nrow(data),
  removing = nrow(pancreas_cases),
  remaining = nrow(data) - nrow(pancreas_cases))

data %>% filter(! (wpocaseid %in% pancreas_cases$wpocaseid))
rm(pancreas_cases)

##### Other non KT cases #####
# list of words to search for
search_terms <- c("wri", "mediastinal",
  "OPEN ABDOMINAL EXPLORATORY LAPAROTOMY",
  "OPEN KIDNEY EXPLORATION", "PHACO",
  "exploratory laparotomy", "ex lap",
  "re-exploration", "washout", "reopening", "re-exploration",
  "ESOPHAGOGASTROSCOPY", "EGD", "DENTAL", "DEBRIDEMENT",
  "colonoscopy", "bleeding", "exploration of renal trans")
```



Kidney Transplant neglected or overlooked(?)



Practice Variations in Intraoperative Fluid Therapy during Kidney Transplantation.

Cases per institution per year (Median [IQR])

110 [52, 173]

Cases per institution per year (Mean $\pm$ SD)

119.0 $\pm$ 79.2

Cases per attending per year (Median [IQR])

2 [1, 3]

Cases per attending per year (Mean $\pm$ SD)

2.8 $\pm$ 2.8

```
removing = nrow(data[proctypecardiac !=
  remaining = nrow(data[proctypecardiac !=
  ##### Liver Transplant ----
  liver_cases <- data %>%
  filter(grepl("liver", ProcedureText, ignore.case = TRUE)) %>%
  select(WPOCcaseID, ProcedureText)

data[proctypexliver[data$WPOCcaseID %in% liver_cases$WPOCcaseID] <- "
count(data, proctypexliver)

cohort_description %>% add_row(description = "Liver Transplant",
  start = nrow(data),
  removing = nrow(data[proctypexliver !=
  remaining = nrow(data[proctypexliver !=

rm(liver_cases)

data %>% filter(proctypexliver != "Yes")
##### Lung Transplant ----
lung_cases <- data %>%
  filter(grepl("lung", ProcedureText, ignore.case = TRUE)) %>%
  select(WPOCcaseID, ProcedureText)
data[proctypelung[data$WPOCcaseID %in% lung_cases$WPOCcaseID] <- "Yes"
count(data, proctypelung)

cohort_description %>% add_row(description = "Lung Transplant",
  start = nrow(data),
  removing = nrow(data[proctypelung ==
  remaining = nrow(data[proctypelung ==

rm(lung_cases)

data %>% filter(proctypelung != "Yes")
##### Pancreas Transplant ----
  filter by Procedure Text:
  pancreas_cases <- data %>%
  filter(grepl("PANCREAS|PANCREATIC", ProcedureText, ignore.case = TRUE))
  select(WPOCcaseID, ProcedureText)

cohort_description %>% add_row(description = "pancreas Transplant",
  start = nrow(data),
  removing = nrow(pancreas_cases),
  remaining = nrow(data) - nrow(pancreas_

data %>% filter(! (WPOCcaseID %in% pancreas_cases$WPOCcaseID))
rm(pancreas_cases)

##### Other non KT cases ----
# list of words to search for
search_terms <- c("MRI", "Mediastinal",
  "OPEN ABDOMINAL EXPLORATORY LAPAROTOMY",
  "OPEN KIDNEY EXPLORATION", "PHACO",
  "exploratory laparotomy", "ex lap",
  "re-exploration", "washout", "REOPENING", "RE-EXPLORATION",
  "ESOPHAGOGASTROSCOPY", "EGD", "DENTAL", "DEBRIDEMENT",
  "Colonoscopy", "bleeding", "Exploration of Renal Transplant")
```

Results:

Balanced crystalloid ratio

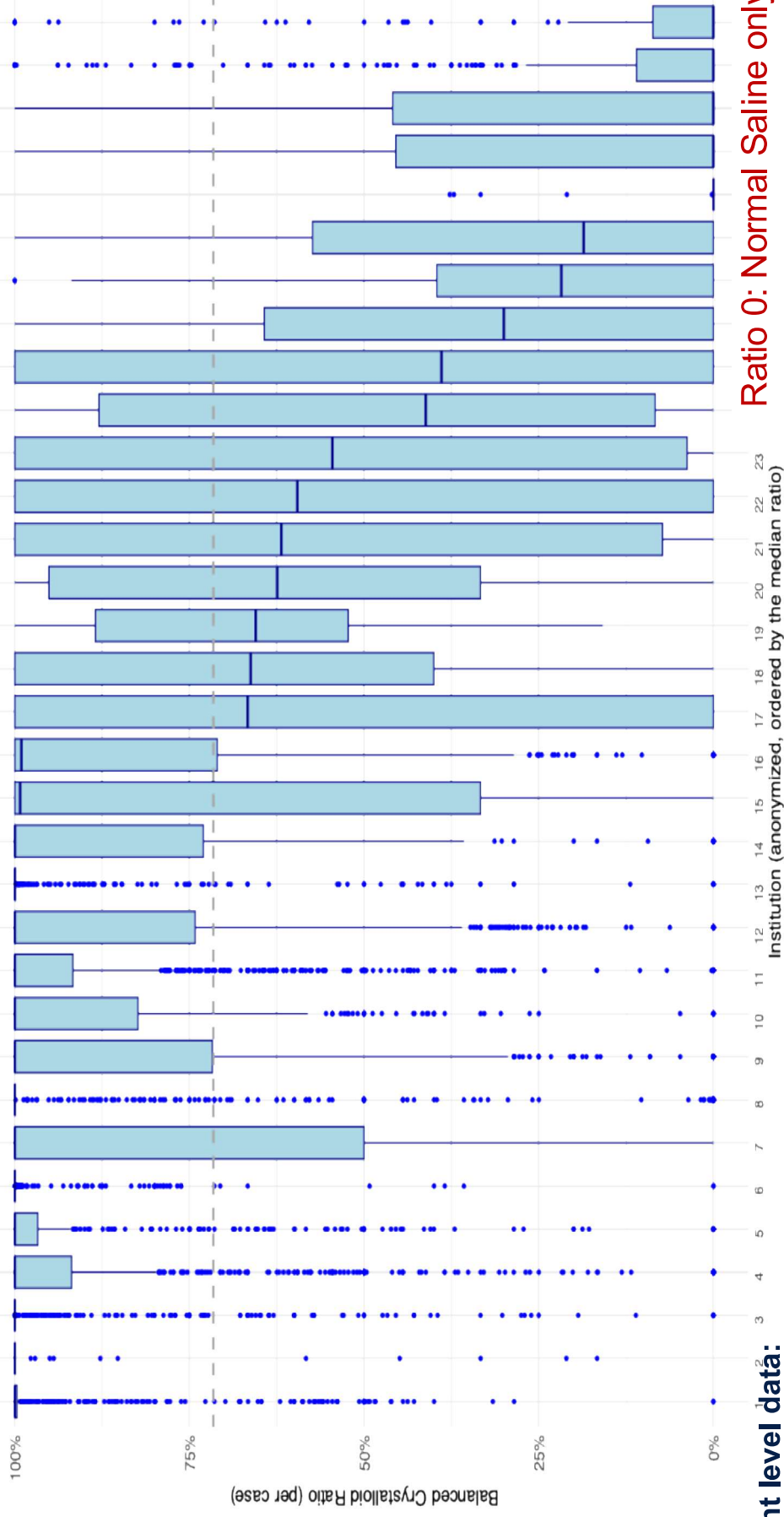
At the **patient level**, the mean balanced crystalloid ratio was 72% (SD 38%), with a median of 100% (IQR 46%–100%).

At the **institution level**, mean ratios ranged from 0% to 99%.

In the random-effects model with institution as the random intercept, we found that **50.9% of the variation in the balanced crystalloid ratio was explained by the institution, while the remaining 49.1% was attributable to patient-level variability.**

Variation in the Balanced Crystalloid Ratio across Institutions

Ratio 1: Balanced Crystalloids only



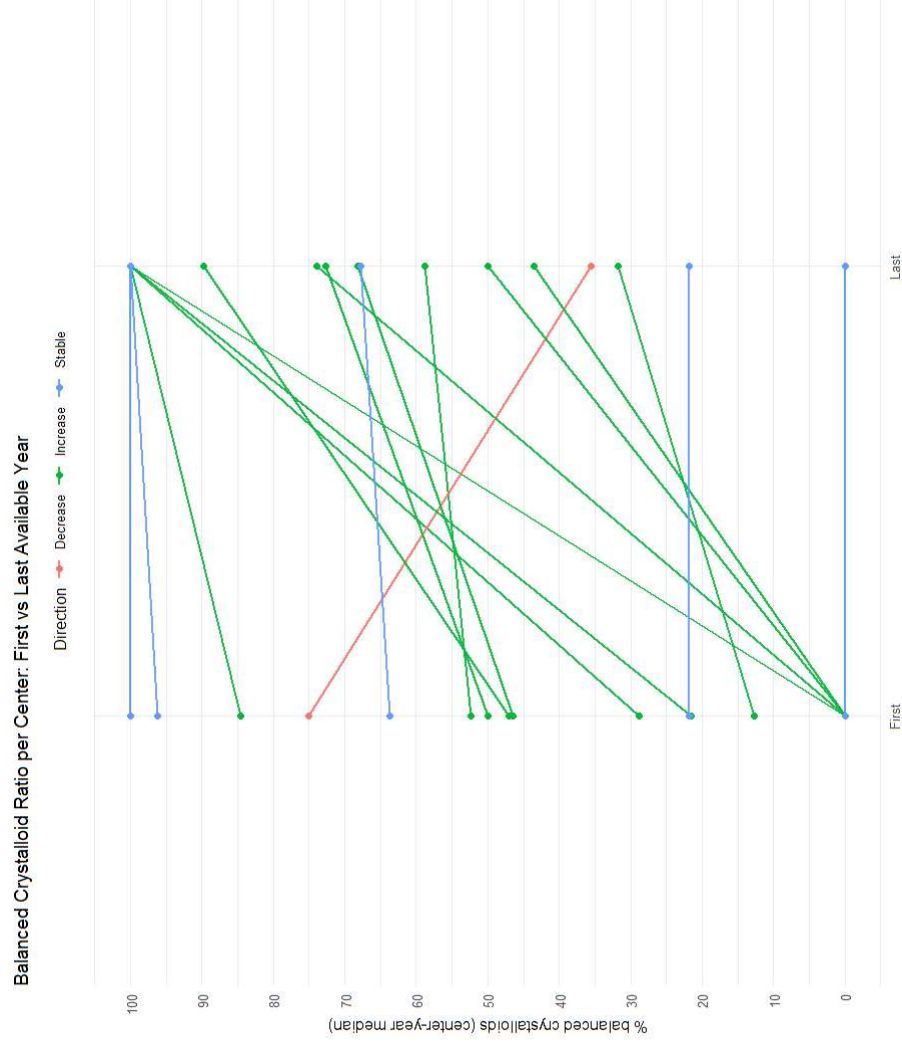
Patient level data:

19,165 Kidney Transplants / 33 US institutions

Ratio 0: Normal Saline only

Adelmann, Douville, Preliminary Data, Manuscript in preparation.

Changes in the Balanced Crystalloid Ratio Over Time

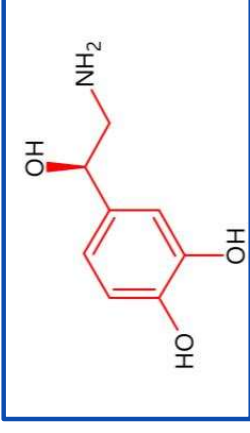


Patient level data:

19,165 Kidney Transplants / 33 US institutions

Adelmann, Douville, Preliminary Data, Manuscript in preparation.

What is next?



Fluids

Balanced
Crystalloids reduce
the risk of DGF.

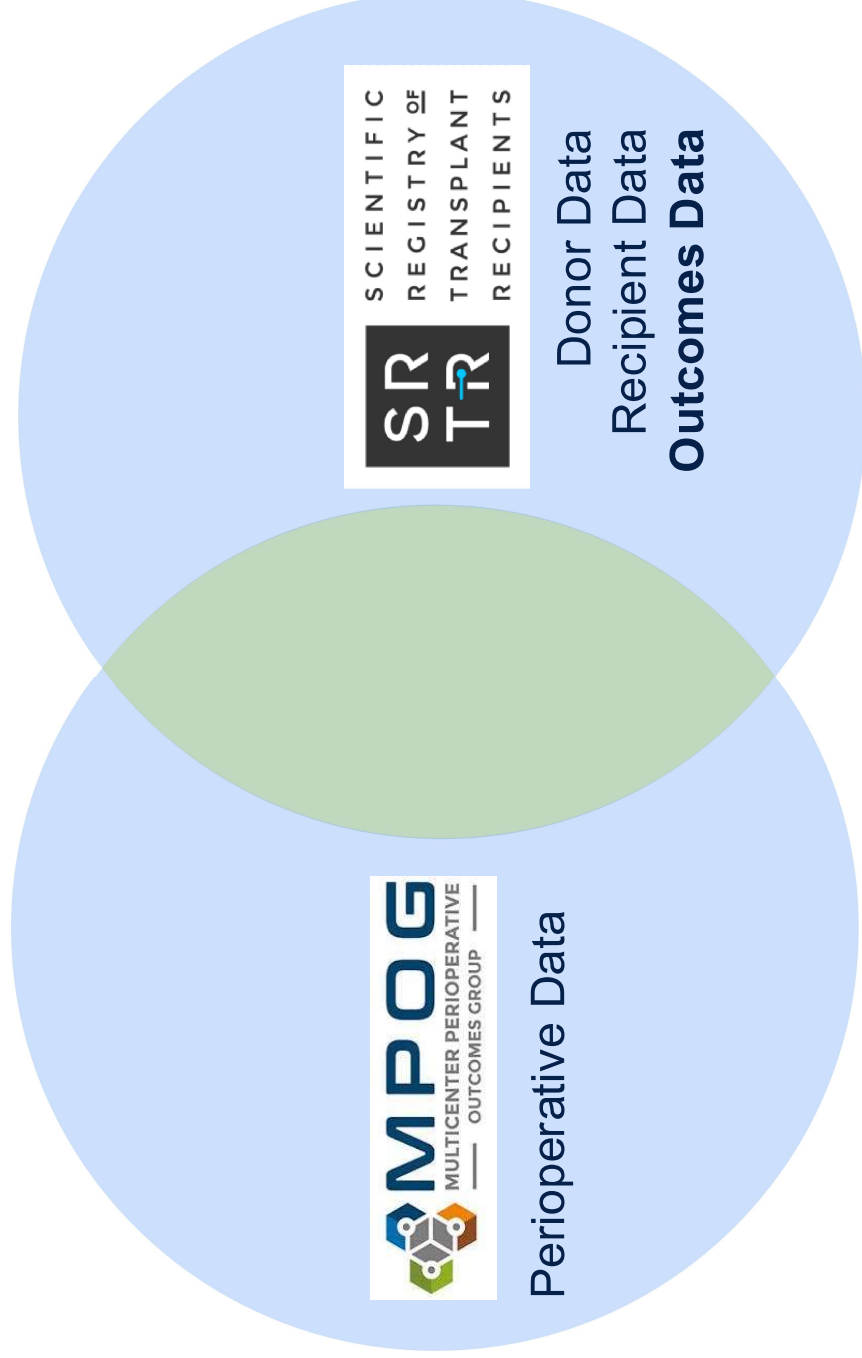
Blood Pressure

PCRC 292
approved

Vasopressors

PCRC 292
approved

What is next?



```
#[3. Start Matching]####
## A. Exact####
data_mpoq[Procedure_Date
data_mpoq[AgeInYears_Value
data_mpoq[Sex_Value

data_matched <- data_mpoq %>% inner_join(data_s
data_matched %>% filter(arm != patient_arm) %>%
data_matched %>% filter(arm != patient_arm) %>%
data_matched %>% filter(arm != data_matched.arm) %>%
data_matched %>%
# select(Height_Value, hgt_on_trr) %>%
# mutate(
#   Height_Value = ceiling(Height_Value),
#   hgt_on_trr = ceiling(as.numeric(hgt_on_trr
#   abs_difference = abs(Height_Value - hgt_o
# ) %>%
#   arrange(desc(abs_difference)) %>% view()

data_mpoq_unmatched <- data_mpoq %>% filter((M
data_star_unmatched <- data_star %>% filter((M
cases_matched %>% add_row(description = c("L
matched_correctly" = nrow
wrong_match = nrow(data
remaining = nrow(data
)

cases_matched
## B. Age + 1####
data_mpoq_unmatched %>%
mutate(AgeInYears_Value_plus1 = AgeInYears_Val
inner_join(data_star_unmatched,
  by = c("Procedure_Date" = "tx_date
  "AgeInYears_Value_plus1" =
  "Sex_Value" = "gender")) %>%
mutate(correct = patient_arm == arm) %>%
count(correct)

data_matched_B <- data_mpoq_unmatched %>%
mutate(AgeInYears_Value_plus1 = AgeInYears_Val
inner_join(data_star_unmatched,
  by = c("Procedure_Date" = "tx_date
  "AgeInYears_Value_plus1" =
  "Sex_Value" = "gender")) %>%
select(AgeInYears_Value_plus1)

data_matched_B %>%
mutate(correct = patient_arm == arm) %>%
count(correct)

data_matched_B[data_matched_B.arm != data_matched
data_matched <- bind_rows(data_matched, data_m
data_mpoq_unmatched <- data_mpoq[filter((M
data_star_unmatched <- data_star[filter((M
```

Summary

- established a cohort of Kidney Transplant Patients in MPOG.
- established a new phenotype to assess classify Crystalloids.
- preparing the first manuscript for publication.
- this is just the beginning of Transplant related research in MPOG.