Revise Nephrology 2023

RENAL TRANSPLANTATION

Dr Jagadish Jamboti

MBBS,MD,DNB, DM,FRACP,FASN,FISN.

Consultant Renal Physician

Fiona Stanley Hospital, Murdoch 6150.

Perth, Western Australia, Australia

University of Western Australia

&

Curtin University

Jagadish.Jamboti@health.wa.gov.au

Outline

- Transplantation vs. Dialysis
- Rejection
- Immunosuppressive Medications
- Complications of RTR: Infections/ NODAT or PTDM
- Malignancy in RTR
- Pregnancy

Why transplant?

- Improved survival
- QOL
- Pregnancy outcomes

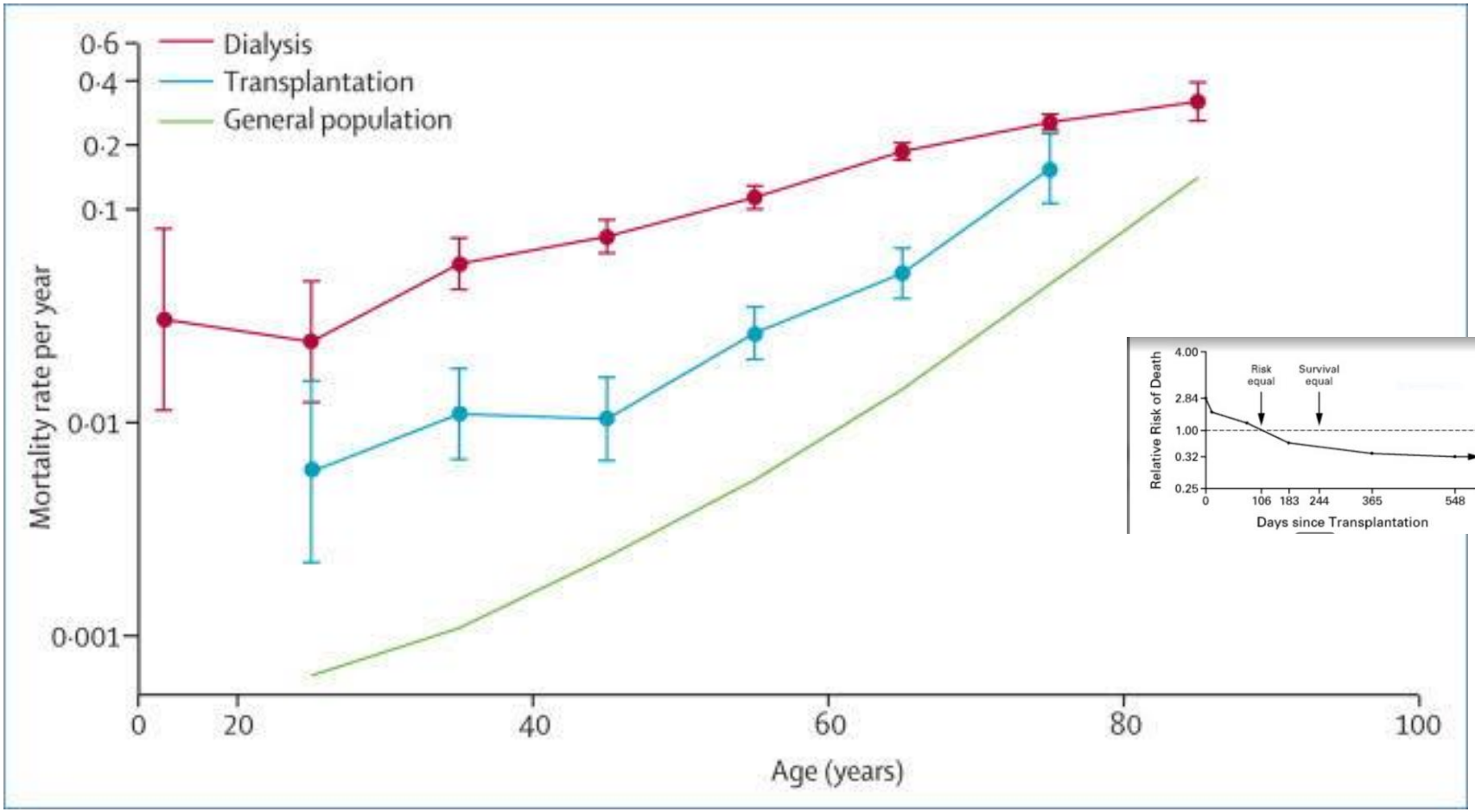
FREEDOM FROM DIALYSIS

FREEDOM TO TRAVEL

PRODUCTIVITY

Economical to the state/ individual

Survival on dialysis vs. Tx



Tx: For whom

ESKD with no contra-indications:

-**Multiple Myeloma, Melanoma**

-Active malignancy

-Active infections

AGE IN ITSELF NOT A CONTRA INDICATION

Kidney Donors

Live Donors

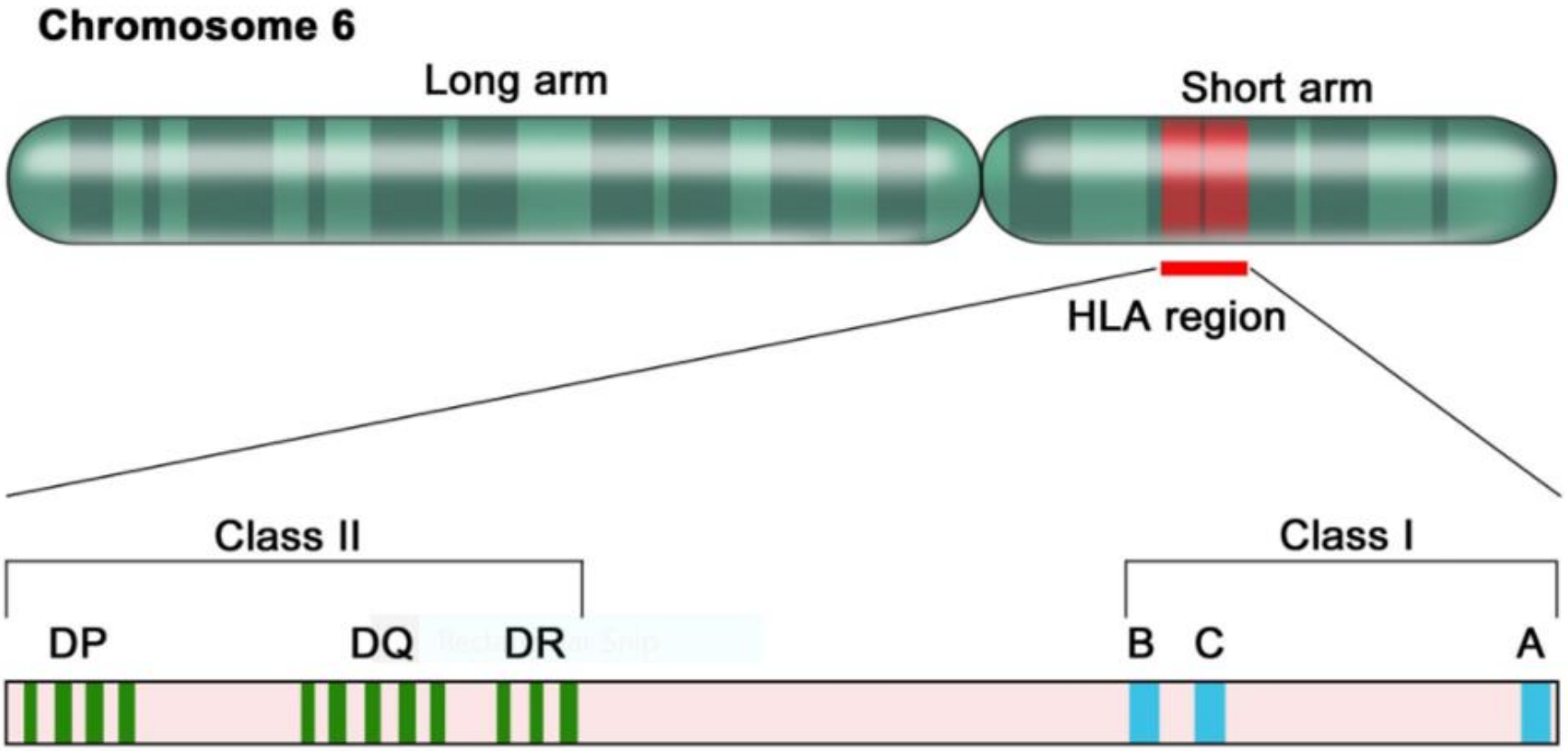
Deceased Donors:

-Donation after Circulatory Determination of Death (**DCDD**)

-Donation after Neurologic Determination of Death (**DNDD**)

Allocation of deceased donor kidneys

- Wait-time since the start of dialysis
- HLA Matching
- Avoid HLA Donor Specific Antibodies (DSA)

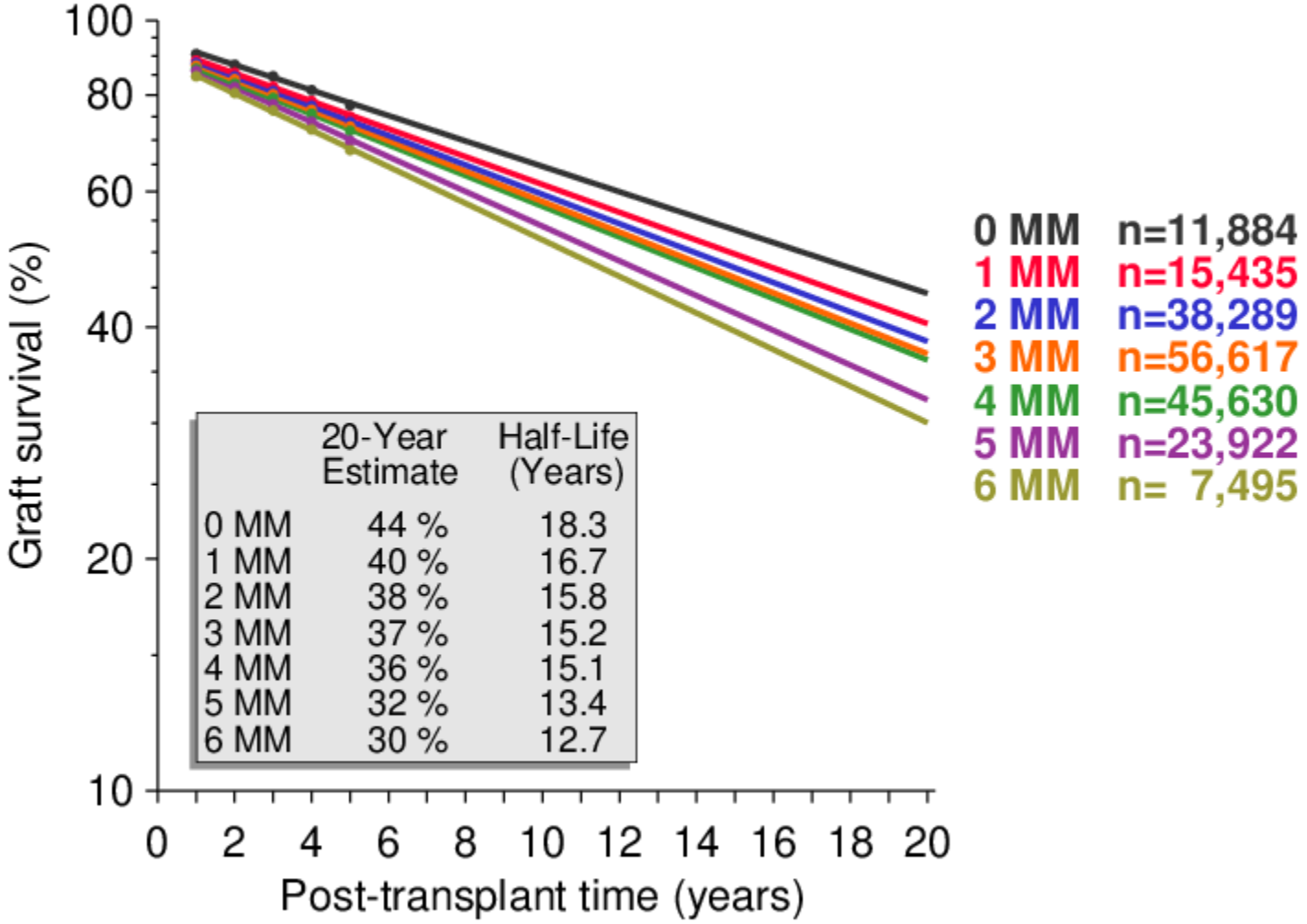


HLA antigens

Immune RECOGNITION:
SELF v/s NON-Self

HLA-A+B+DR Mismatches

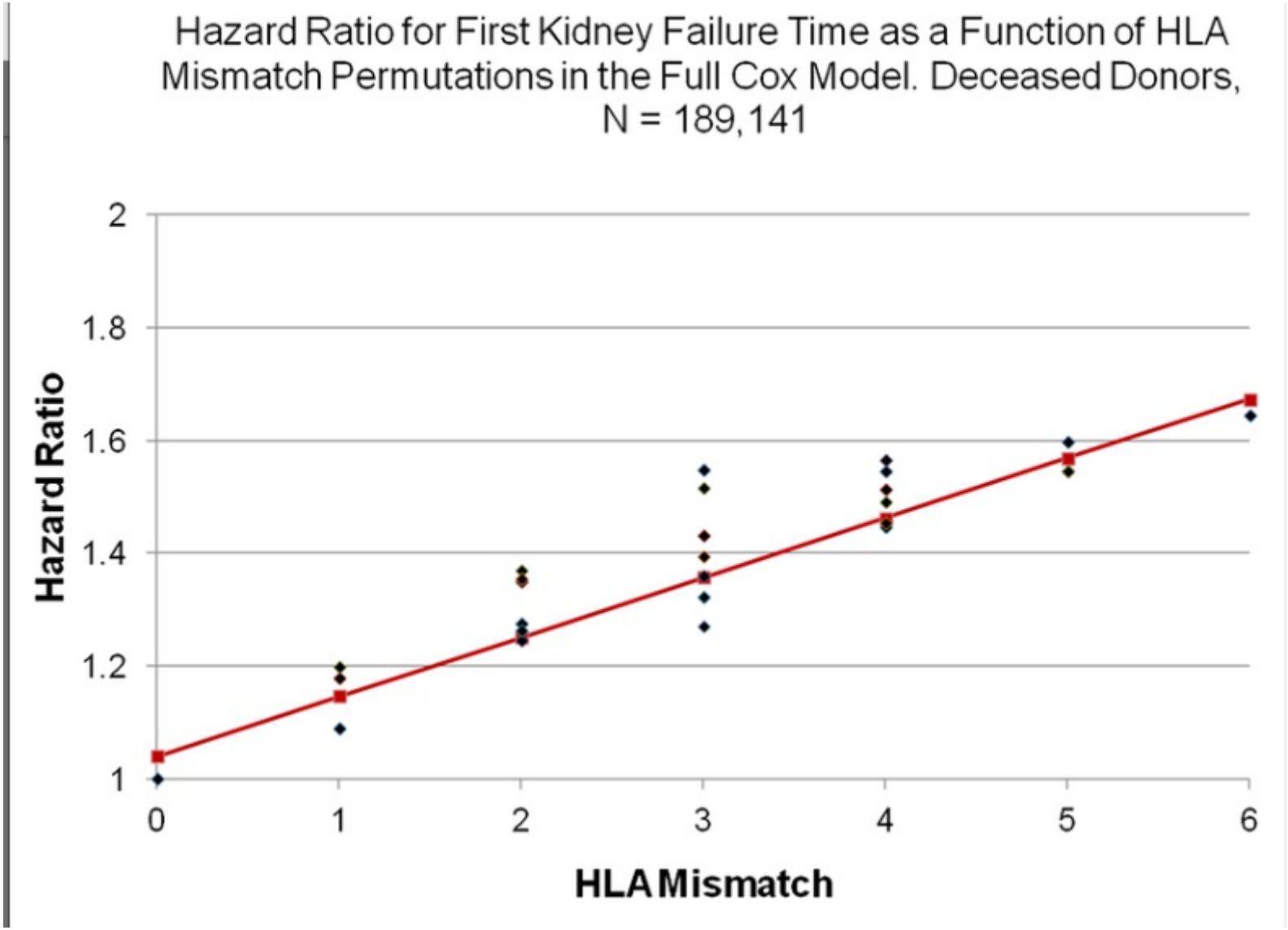
Deceased Donor, First Kidney Transplants 1990-2015

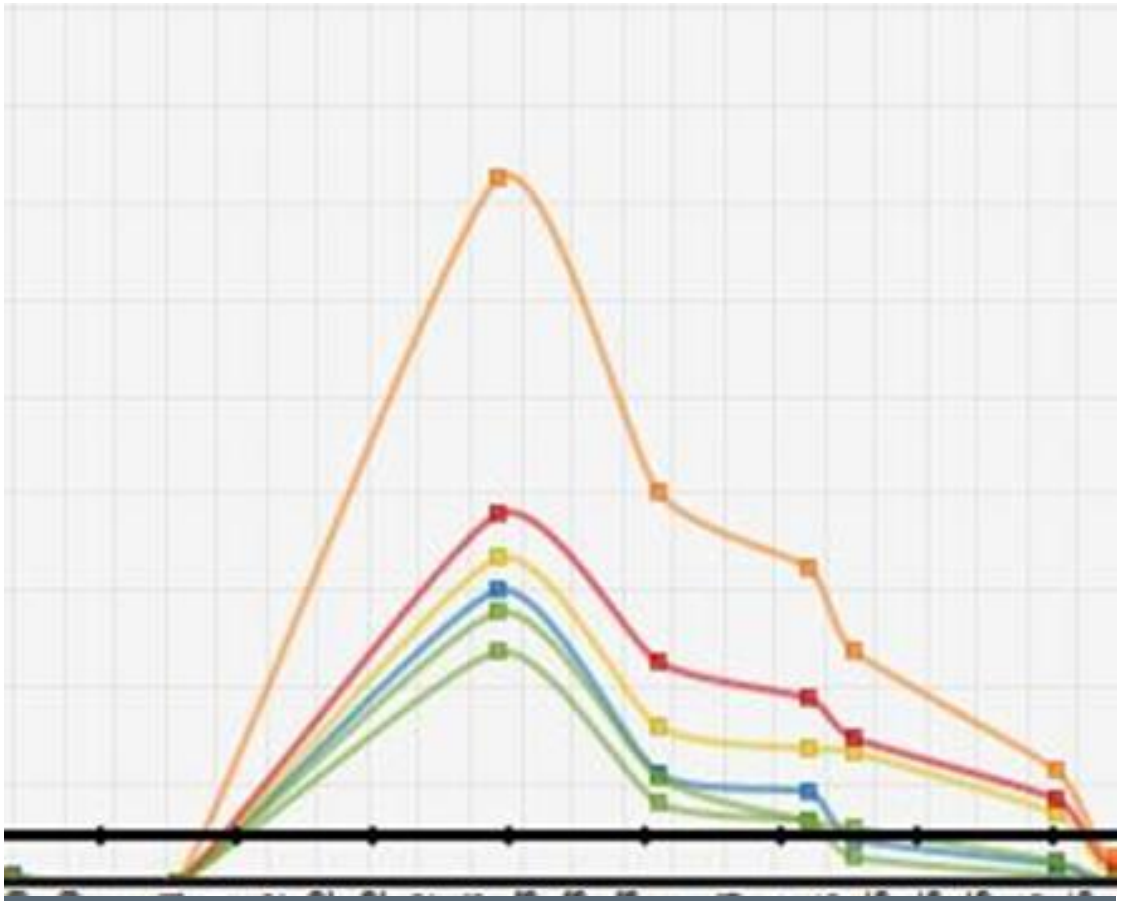


	20-Year Estimate	Half-Life (Years)
0 MM	44 %	18.3
1 MM	40 %	16.7
2 MM	38 %	15.8
3 MM	37 %	15.2
4 MM	36 %	15.1
5 MM	32 %	13.4
6 MM	30 %	12.7

The Risk of Transplant Failure With HLA Mismatch in First Adult Kidney Allografts From Deceased Donors

Williams et al., TRANSPLANTATION 2016: 100(5); 1094-1102

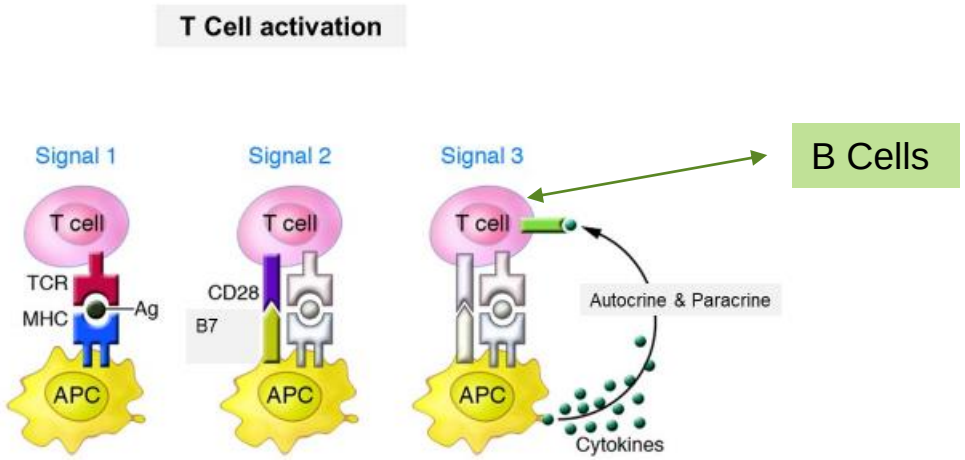




HLA Antibodies: sensitizing events

- Blood transfusions
- Previous Transplant
- Pregnancy

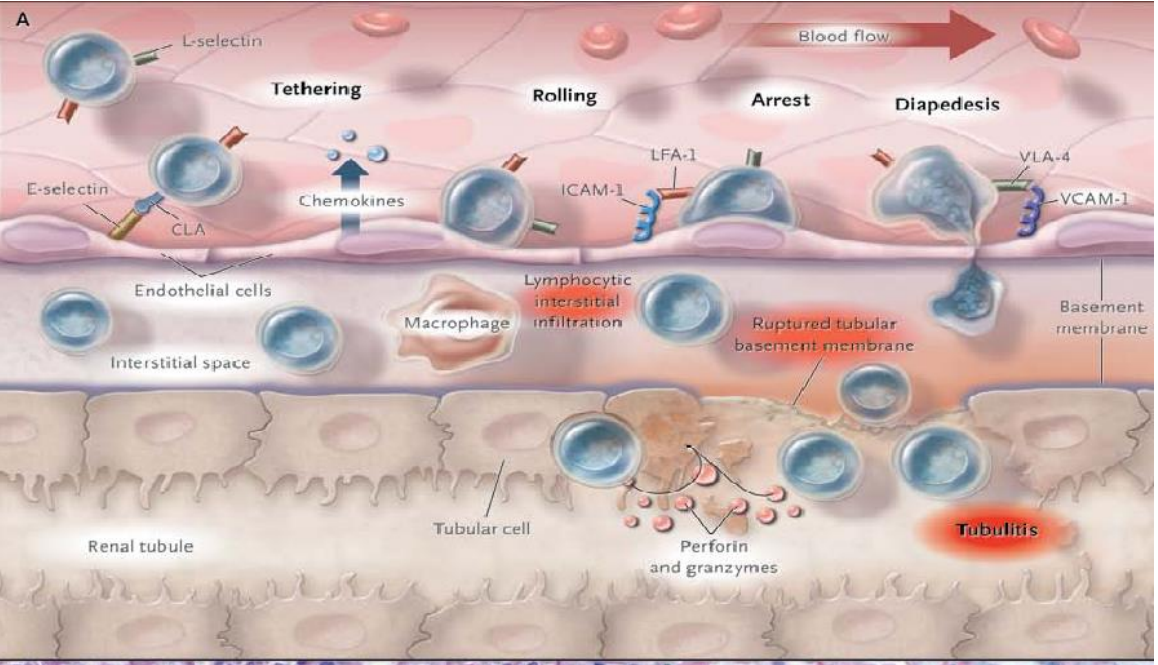
Immune recognition & Types of Rejection

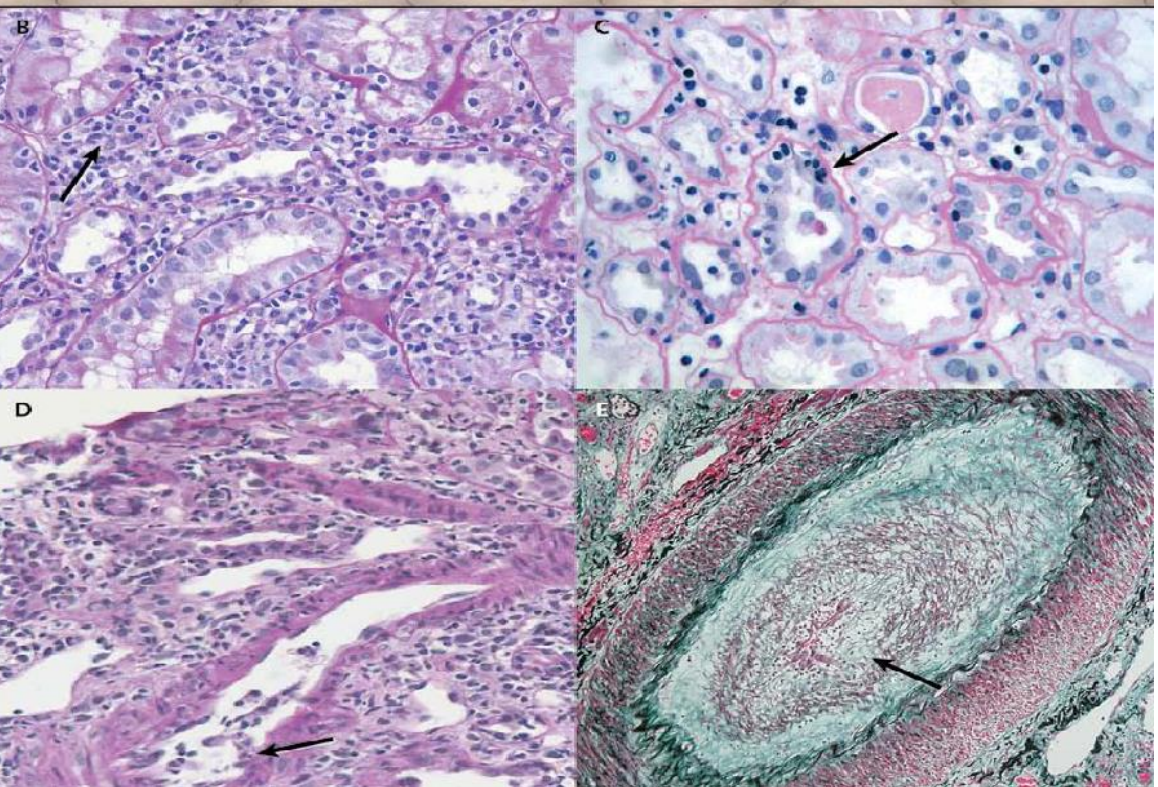


T-cell mediated

Antibody mediated

Acute T-Cell–Mediated Rejection.

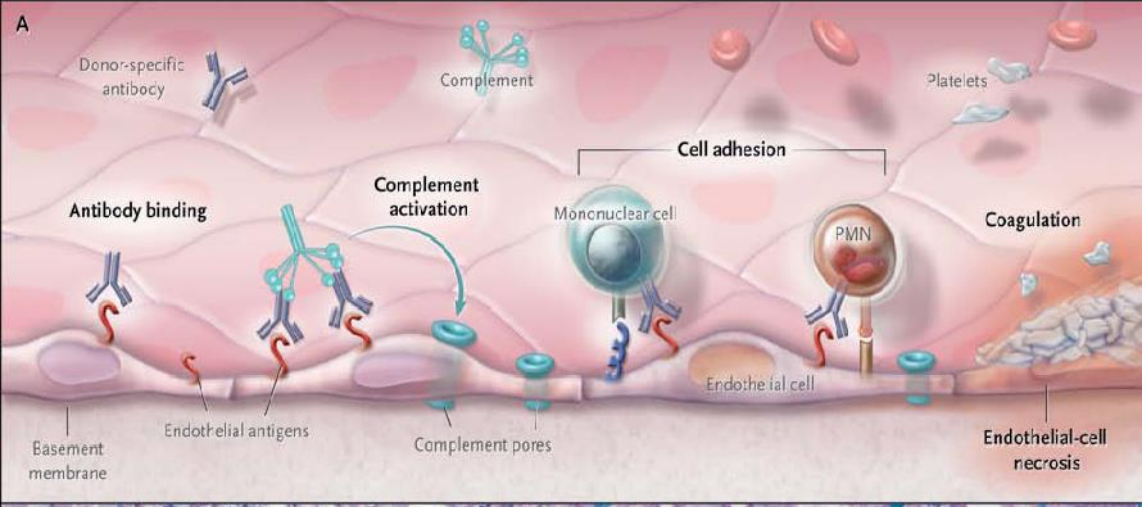


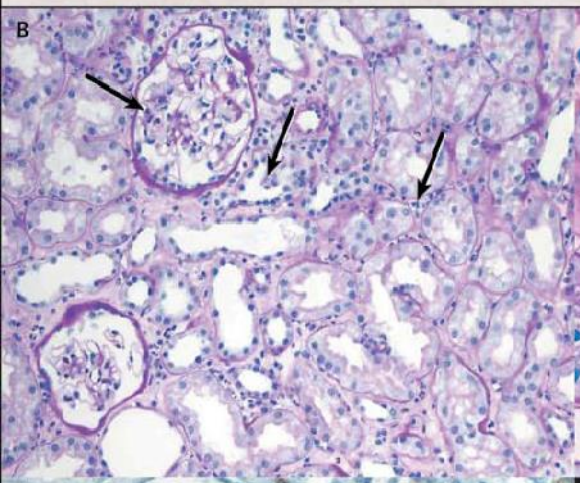


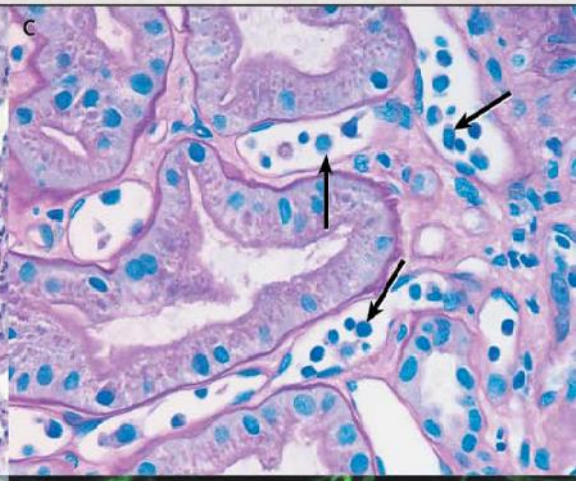
NEJM October 7, 2010
BJ Nankivell
and
SI Alexander

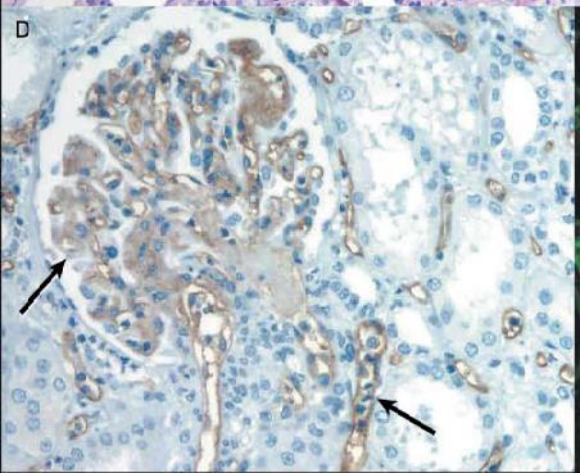
***Tubulitis**
***Interstitial inflammation**

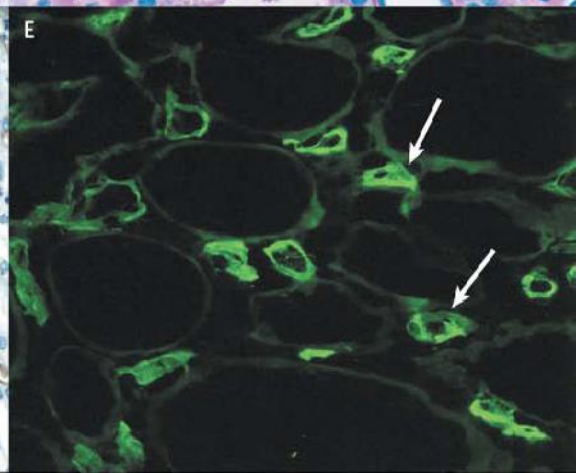
Acute Antibody-Mediated Rejection.







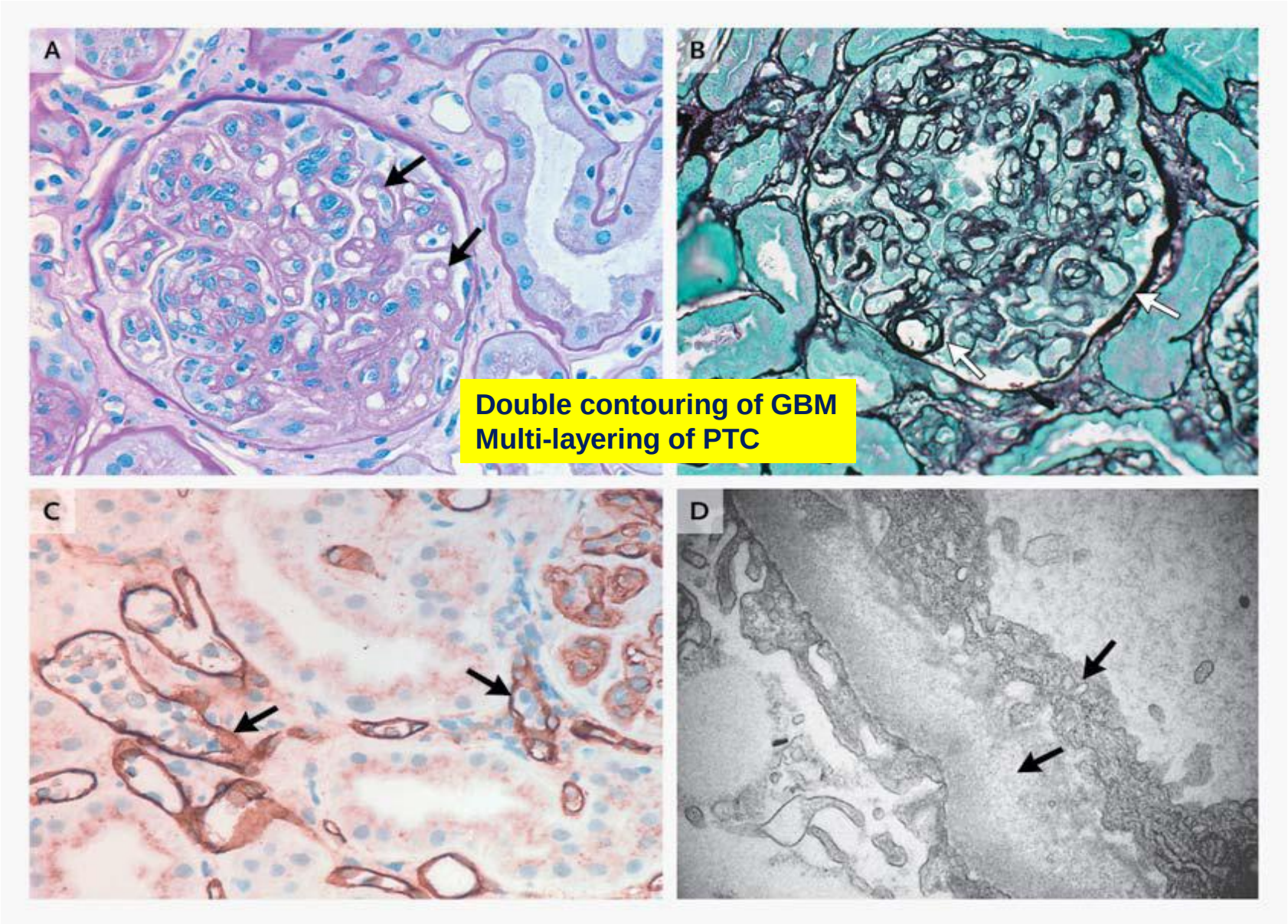




***Glomerulitis**
***Peri-tubular Capillaritis**
***C4d deposition on IF in PTC**

NEJM October 7, 2010
BJ Nankivell and SI Alexander

Chronic Antibody-Mediated Rejection.



Rejection: Treatment

Acute T-Cell Mediated Rejection (Acute cellular Rejection-ACR)

*IV Methyl Prednisolone/Oral Pred

*Optimize Immunosuppression

Steroid resistant ACR → ATG

Acute Antibody Mediated Rejection (AMR)

*IVIG

*PLASMA EXCHANGE

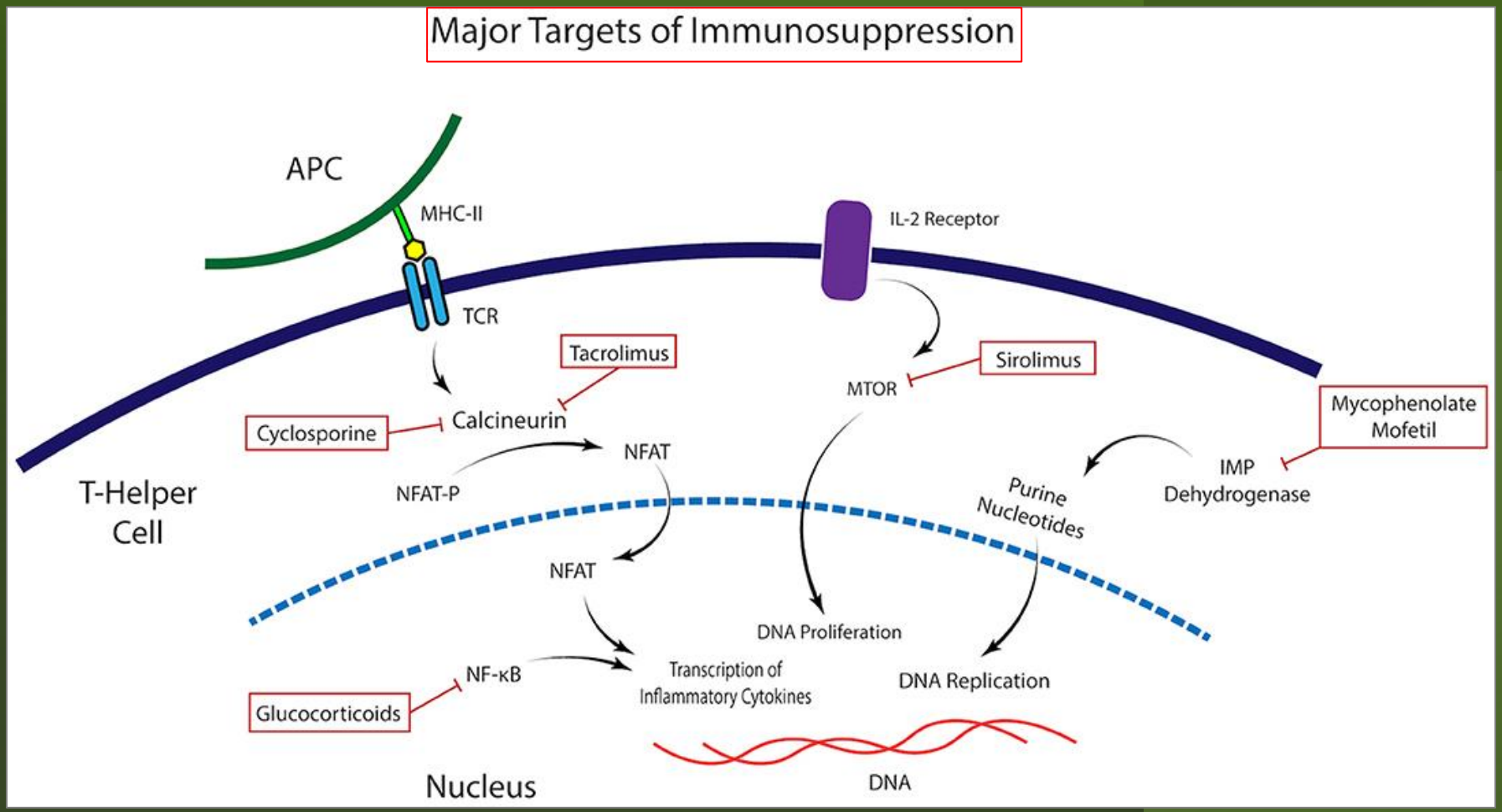
Chronic Antibody Mediated Rejection

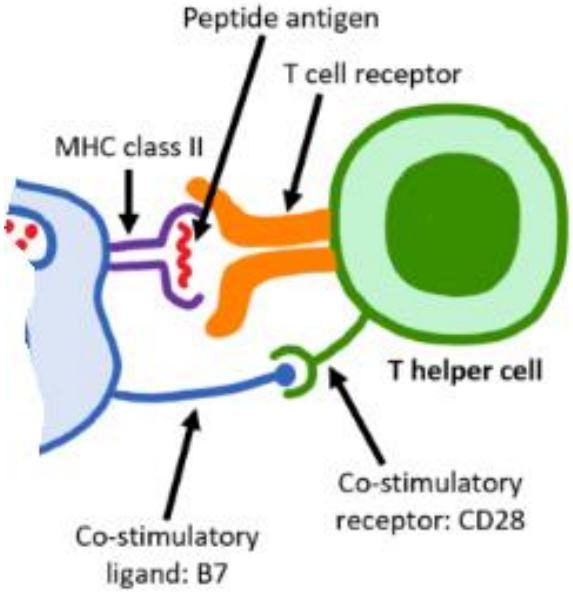
*IVIG

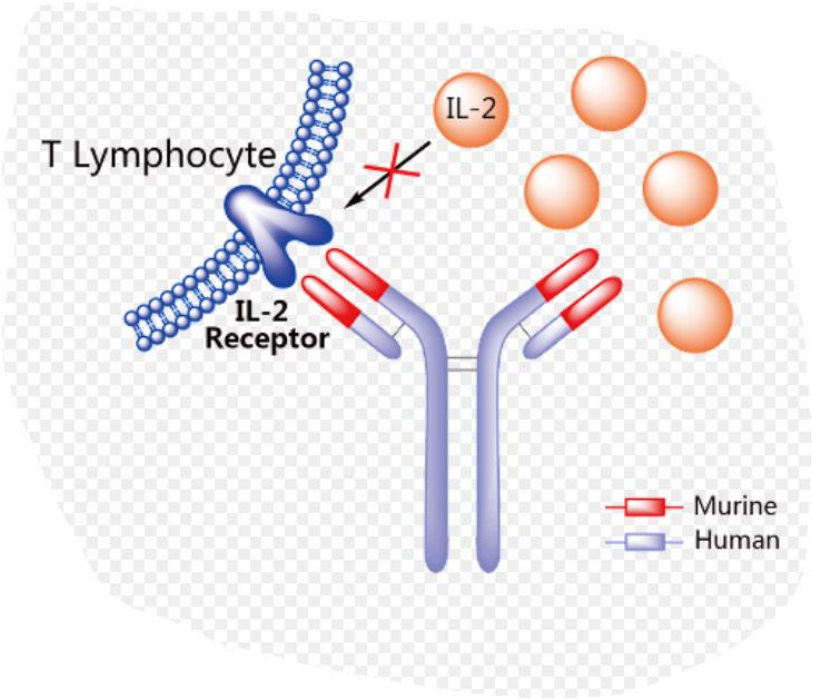
*PLASMA EXCHANGE

*TOCILIZUMAB

Major Targets of Immunosuppression







Co-stimulatory blockade

- **CD 28: Belatacept**
- **CD 25: Basiliximab**

Immunosuppressants: Modes of Action

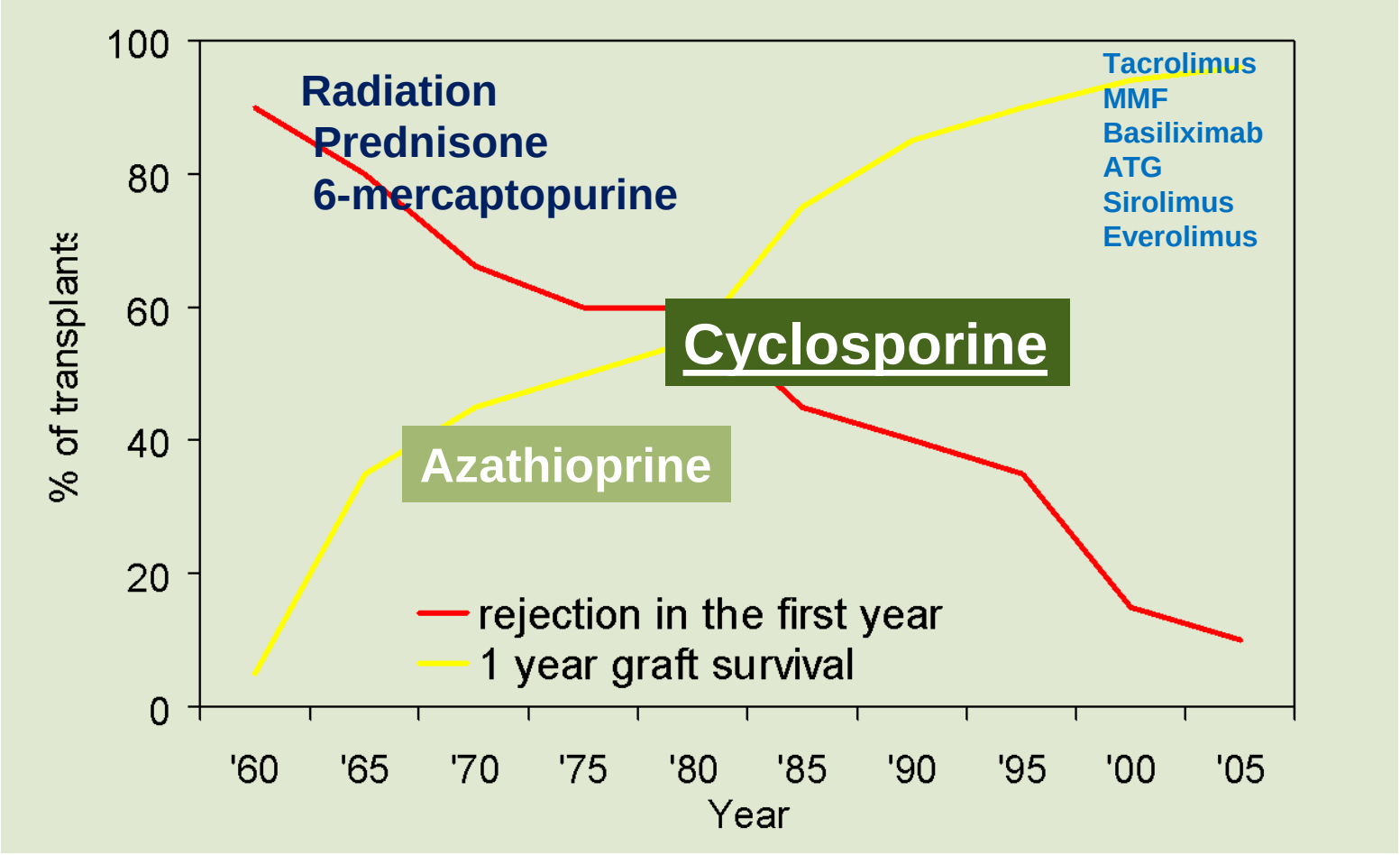
- **Calcineurin inhibitors**
  - Cyclosporine
  - Tacrolimus
- **Purine synthesis inhibitors**
  - Azathioprine
  - Mycophenolate

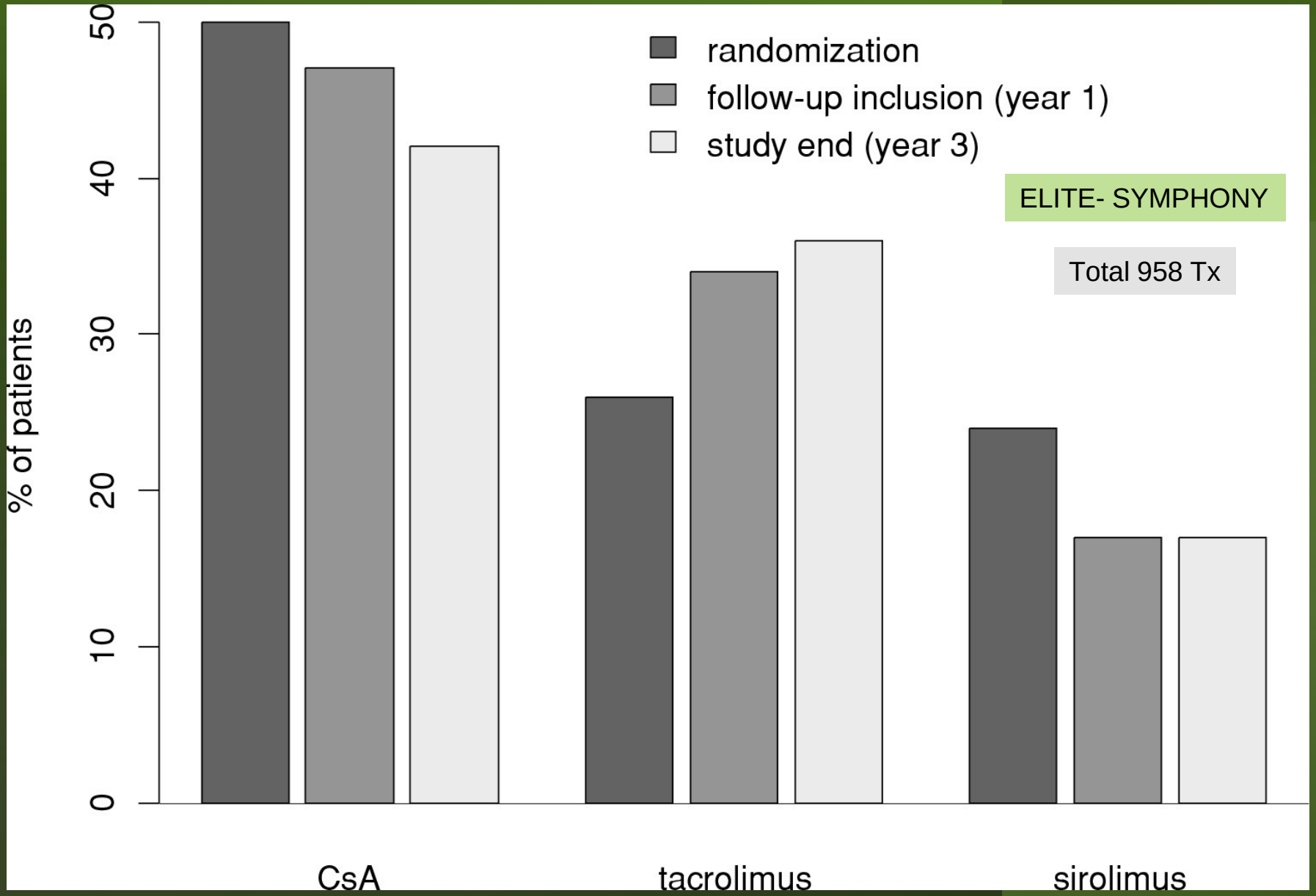
Nonspecific

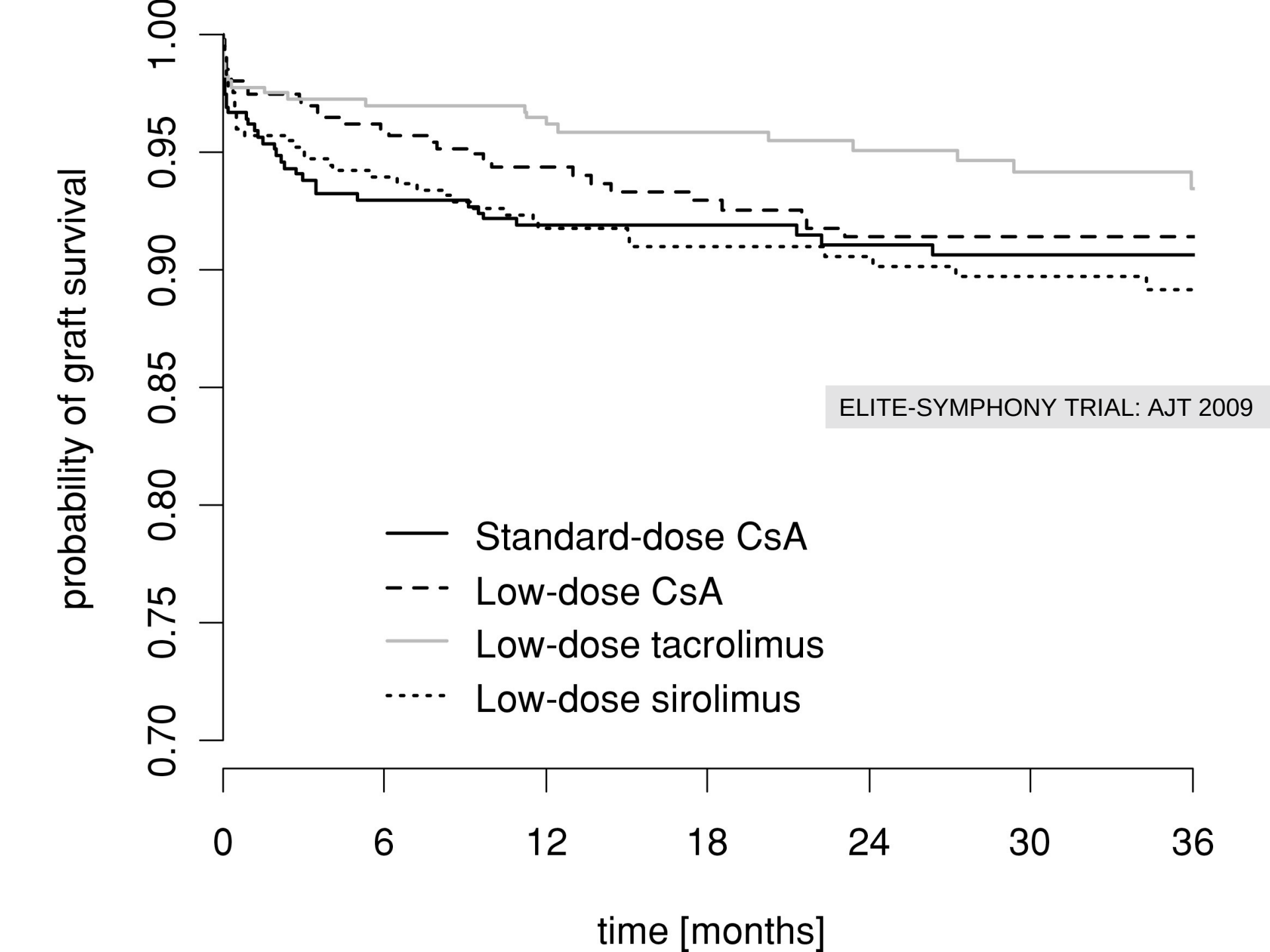
- Prednisolone

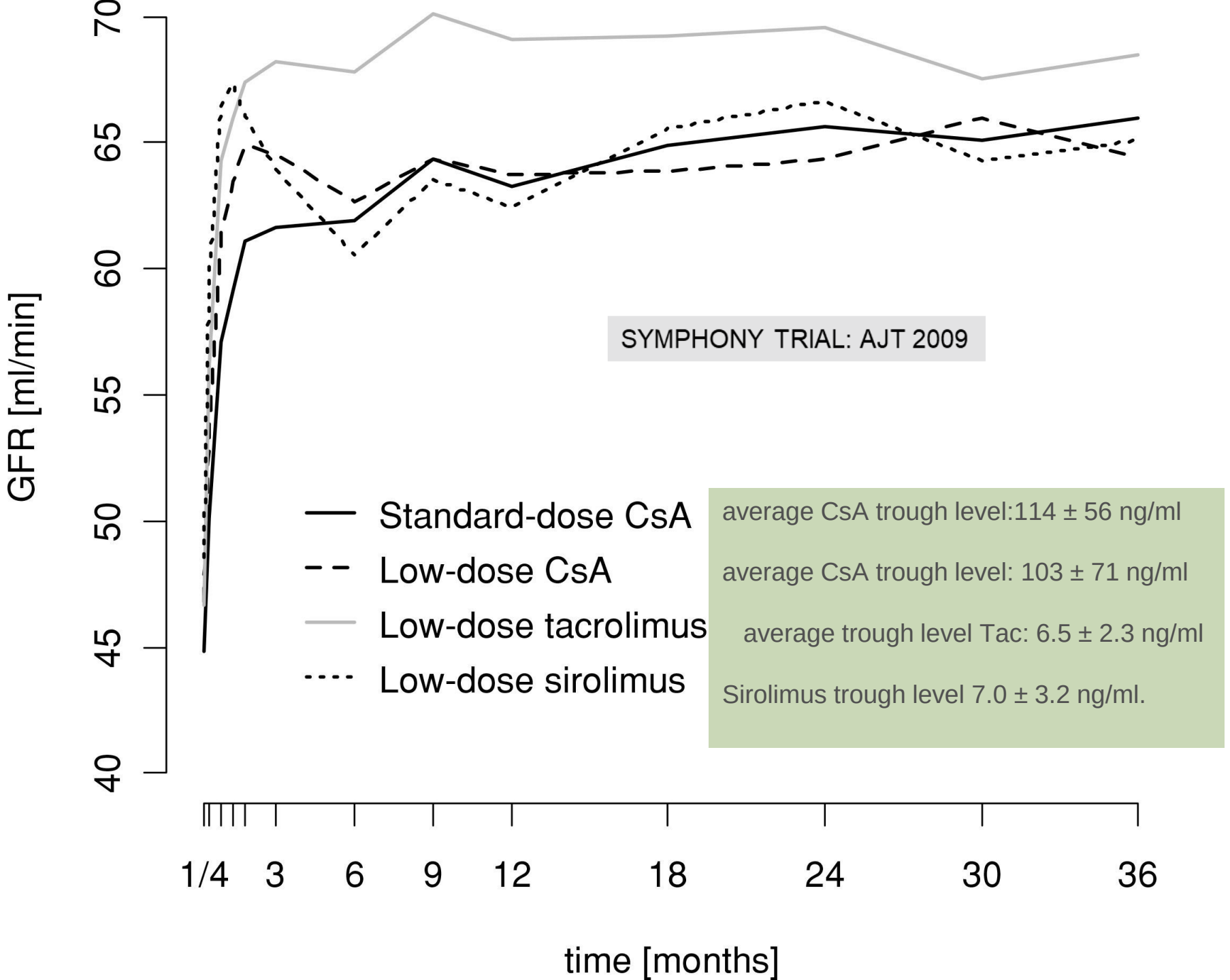
- **Target of Rapamycin inhibitor (mTORi)**
  - Sirolimus/ Everolimus
- **Monoclonal Antibodies**
  - Blocks IL-2 receptor- Basiliximab
  - Blocks CD 28- Belatacept
- **Polyclonal antibodies**
  - Thymoglobulin ®
- B Cell Depletion: Rituximab
- Plasma cell Depletion: Bortezomib
- Plasma Exchange
- IVIG

Circa BC and after…



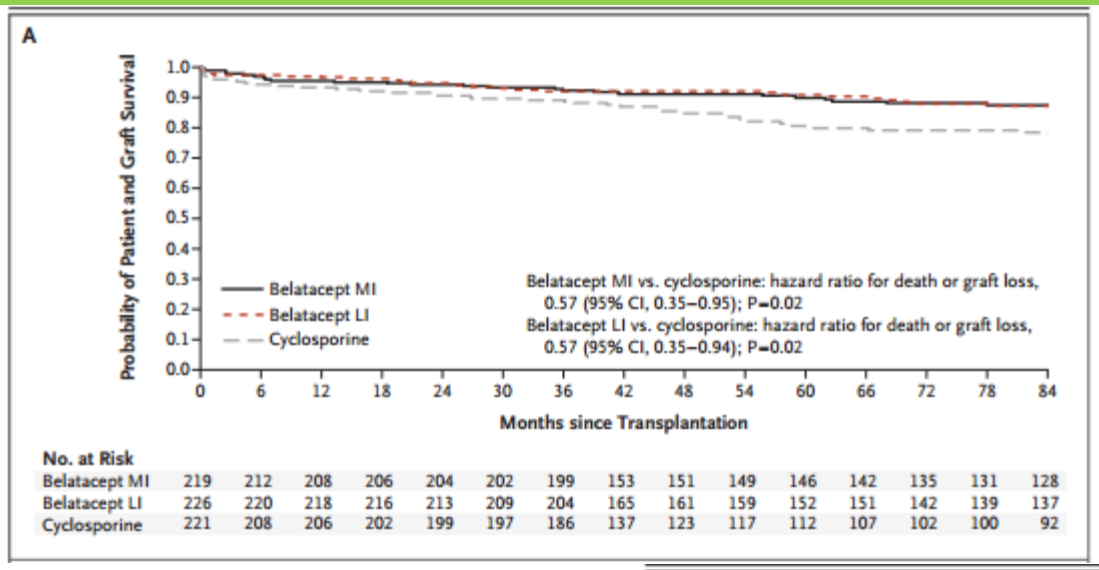

randomization
follow-up inclusion (year 1)
study end (year 3)
ELITE- SYMPHONY
Total 958 Tx
% of patients
0
10
20
30
40
50
CsA
tacrolimus
sirolimus


probability of graft survival
1.00
0.95
0.90
0.85
0.80
0.75
0.70
ELITE-SYMPHONY TRIAL: AJT 2009
Standard-dose CsA
Low-dose CsA
Low-dose tacrolimus
Low-dose sirolimus
0
6
12
18
24
30
36
time [months]


GFR [ml/min]
40
45
50
55
60
65
70
SYMPHONY TRIAL: AJT 2009
Standard-dose CsA
Low-dose CsA
Low-dose tacrolimus
Low-dose sirolimus
average CsA trough level:114 ± 56 ng/ml
average CsA trough level: 103 ± 71 ng/ml
average trough level Tac: 6.5 ± 2.3 ng/ml
Sirolimus trough level 7.0 ± 3.2 ng/ml.
1/4
3
6
9
12
18
24
30
36
time [months]

Belatacept and Long-Term Outcomes in Kidney Transplantation

NEJM Jan 28, 2016



BENEFIT STUDY
7 years follow up

To prevent Chronic CNI Toxicity

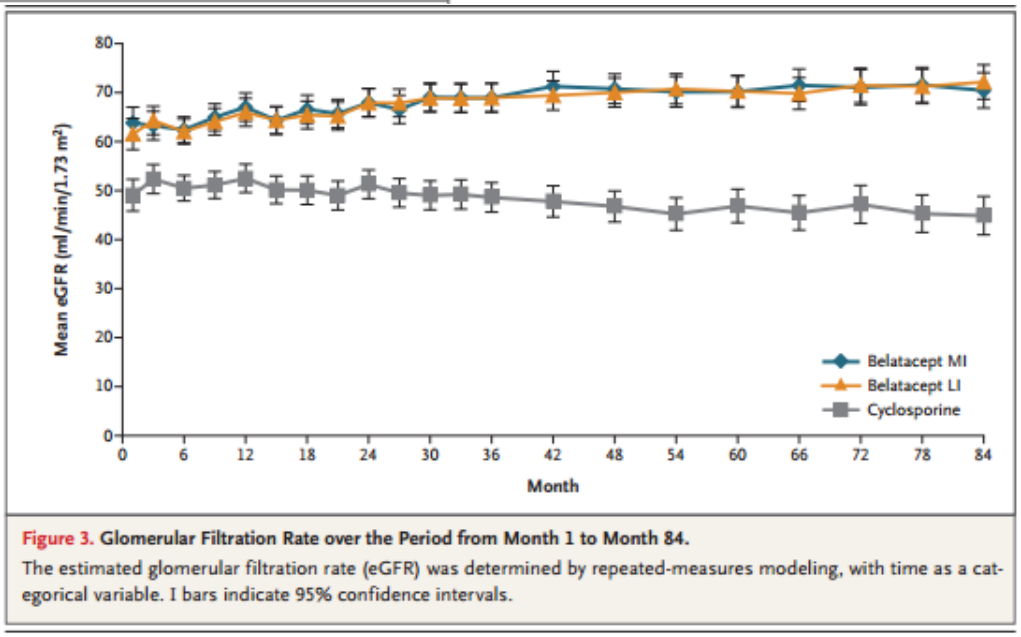


Figure 3. Glomerular Filtration Rate over the Period from Month 1 to Month 84.
The estimated glomerular filtration rate (eGFR) was determined by repeated-measures modeling, with time as a categorical variable. I bars indicate 95% confidence intervals.

Immunosuppressive medications: Common side effects

CNI

- HTN
- Cholesterol
- NODAT
- Neurologic
- Viral Infections

mTORi

- Delayed Wound Healing
- Lymphocele
- NODAT
- Proteinuria

Corticosteroids

- Osteoporosis
- NODAT

Anti-Proliferative Agents

AZATHIOPRINE

- Bone marrow suppression
- Skin Cancers

MYCOPHENOLATE

- GI side effects
- Bone Marrow suppression

Side Effect	Cyclosporine	Tacrolimus	Sirolimus/Everolimus
Nephrotoxicity	++	+	+
Neurotoxicity (tremors, seizures)	+	++	-
Hirsutism	++	---	-
Gingival hyperplasia	+	-	-
Hypertension	++	+	-
Hyperlipidaemia	++	+/-	+++
Glucose intolerance	+	+++	++
Bone marrow suppression	-	-	++
Lymphocele	-	-	+++
Delayed Wound healing	-	-	+++

Disease recurrence in a Tx Recipient

25year old male on HD for 1 year

ESKD sec to FSGS: First diagnosed at year 21; heavy proteinuria- proceeded to ESKD despite Rx over 3 years

Elder brother aged 32 years, 1 haplotype match donor

Immediate Tx function: excellent. Serum creatinine 90.

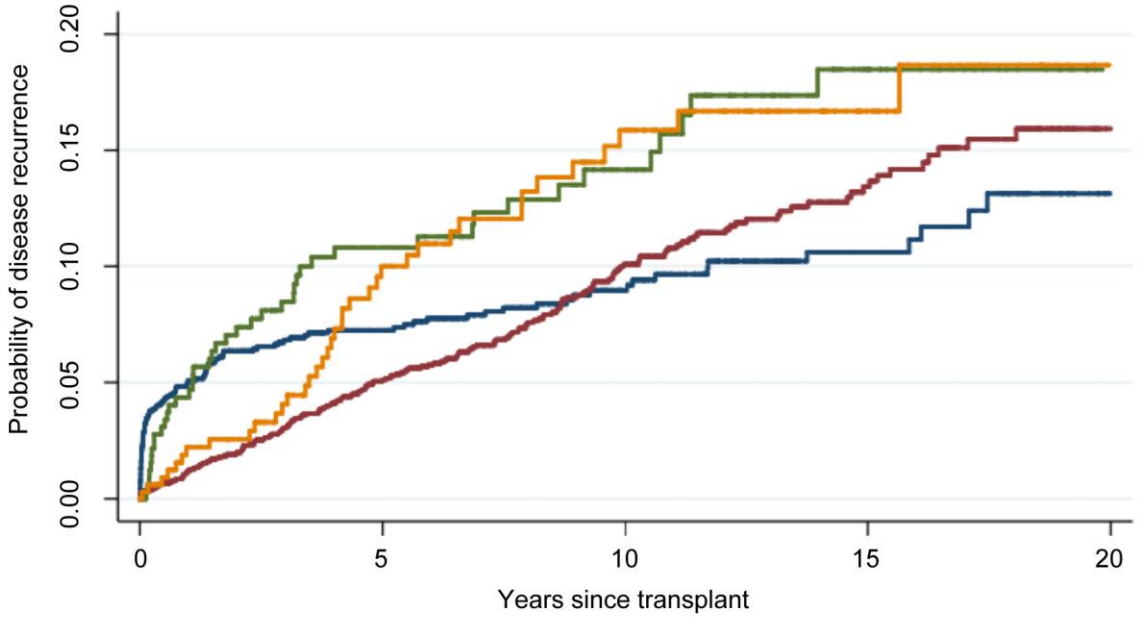
Presents with oedema, uPCR 250, serum creatinine 167. BP: 150/96 after 3 months of Tx.

Highest risk of graft failure is due to recurrence of

- IgA
- Membranous Nephropathy
- Primary FSGS
- Fabry's disease

Recurrent GN after kidney transplantation: risk factors and allograft outcomes

Penelope J. Allen, Steve J. Chadban, Jonathan C. Craig, Wai H. Lim, Richard D.M. Allen, Philip A. Clayton, Armando Teixeira-Pinto, Germaine Wong



Number at risk

FSGS	1653	769	412	194	67
IgA nephropathy	2451	1543	836	365	115
MPGN	352	201	122	63	35
Membranous	340	194	121	51	13

Kidney International **2017 92461-469** DOI: (10.1016/j.kint.2017.03.015)

DGF: COVID & Delays in transport

A deceased-donor kidney from a donor with anoxic brain injury and brain death is to be shipped from Cairns to Perth for a patient with a cPRA of 98%. The expected cold ischemia time is 26 hours, increasing concern for delayed graft function once transplanted.

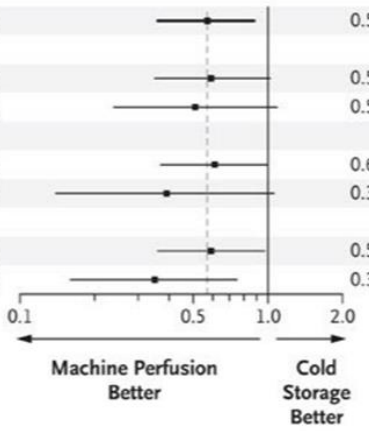
Which ONE of the following interventions has been shown to REDUCE the risk of delayed graft function?

A. Hypothermic machine perfusion (HMP) of the explanted kidney
B. Dopamine infusion of the donor before procurement
C. Remote ischemic conditioning of the recipient (thigh occlusion)
D. Complement inhibition of the recipient at the time of transplant

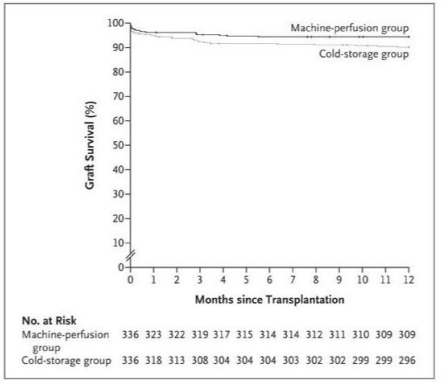
E. Combined Donor Hypothermia & Hypothermic Machine Perfusion

cPRA=Calculated Panel reactive Antibodies

Subgroup	No. of Patients (%)	Machine-Perfusion Group	Cold-Storage Group	Adjusted Odds Ratio (95% CI)	P Value
		no. of events (%)			
Overall	672 (100)	70 (21)	89 (27)	0.57 (0.36–0.88)	
Donor criteria					0.75
Standard-criteria donation	484 (72)	48 (20)	60 (25)	0.59 (0.35–1.02)	
Expanded-criteria donation	188 (28)	22 (23)	29 (31)	0.51 (0.24–1.09)	
Donation procedure (main data set)					0.42
Donation after brain death	588 (88)	48 (16)	61 (21)	0.61 (0.37–1.00)	
Donation after cardiocirculatory death	84 (13)	22 (52)	28 (67)	0.39 (0.14–1.06)	
Donation procedure (extended data set)					0.26
Donation after brain death	588 (78)	48 (16)	61 (21)	0.59 (0.36–0.97)	
Donation after cardiocirculatory death	164 (22)	44 (54)	57 (70)	0.35 (0.16–0.75)	



Hypothermic machine perfusion was associated with a reduced risk of delayed graft function *and* improved graft survival in the first year after transplantation



NEJM Jan 2009: *Cyril Moers et al.,*

725 DBD donors, 1349 kidneys transplanted:
359 kidneys in the donor hypothermia group
511 in the hypothermic machine-perfusion group
479 in the combined-therapy group.

2017-2020 US

NEJM Feb 2023

DGF=Requiring dialysis within 7 days of Tx

Hypothermia or Machine Perfusion in Kidney Donors

Malinoski D et al. DOI: 10.1056/NEJMoa2118265

CLINICAL PROBLEM

The use of hypothermia in brain-dead organ donors has been shown to reduce the incidence of delayed graft function in kidney recipients. A similar effect has been estimated for ex situ hypothermic machine perfusion of donor kidneys, but this intervention involves substantial logistic and cost hurdles. Whether donor hypothermia is as effective as machine perfusion in protecting against delayed graft function is unclear.

CLINICAL TRIAL

Design: A pragmatic, prospective, adaptive, randomized trial conducted at six organ-procurement facilities in the United States assessed whether hypothermia in the donor was noninferior to ex situ hypothermic machine perfusion of donor kidney and whether the combination of interventions was superior to either one alone.

Intervention: 1349 kidneys from 725 brain-dead organ donors were randomly assigned to ex situ hypothermic machine perfusion alone, targeted mild hypothermia (34 to 35°C) in the donor alone, or both. Donors were ≥18 years of age; their condition was hemodynamically stable on low-dose vasopressors, with a mean arterial pressure of >60 mm Hg. The primary end point was delayed graft function in the kidney transplant recipients, which was defined as the initiation of dialysis in the kidney recipient during the first week after transplantation. Graft failure at 1 year was also assessed.

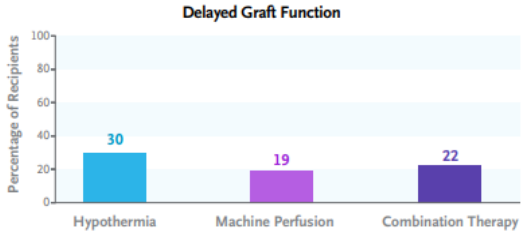
RESULTS

Therapeutic hypothermia alone was inferior to machine perfusion alone in reducing delayed graft function. A combination of therapeutic hypothermia and machine perfusion was not superior to machine perfusion alone.

LIMITATIONS AND REMAINING QUESTIONS

- Clinicians caring for brain-dead patients were aware of the intervention assignment. The investigators were not involved in assessing outcomes.

Links: Full Article | NEJM Quick Take | Editorial



Primary and Key Secondary Kidney Graft Outcomes

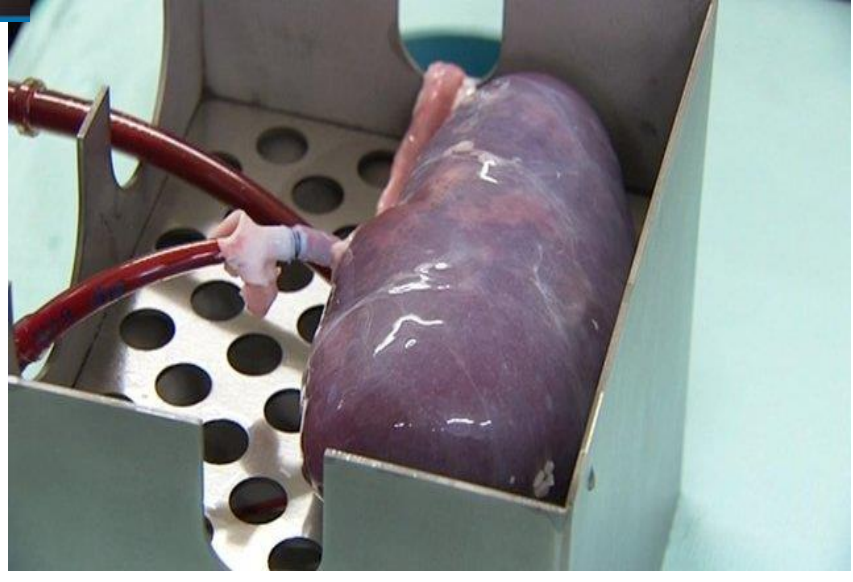
Variable	Treatment Effect (95% CI)* Unadjusted	Adjusted
Delayed graft function		
Hypothermia vs. machine perfusion	1.56 (1.23–1.98)	1.72 (1.35–2.17)
Hypothermia vs. combination therapy	1.41 (1.12–1.78)	1.57 (1.26–1.96)
Combination therapy vs. machine perfusion	1.11 (0.87–1.42)	1.09 (0.85–1.40)
Graft failure at 1 year		
Hypothermia vs. machine perfusion	0.74 (0.33–1.66)	NA
Hypothermia vs. combination therapy	0.91 (0.40–2.06)	NA
Combination therapy vs. machine perfusion	0.82 (0.40–1.67)	NA

* The treatment effect was calculated as a risk ratio for delayed graft function and as a hazard ratio for graft failure at 1 year.

CONCLUSIONS

Hypothermia in brain-dead kidney donors was inferior to ex situ hypothermic machine perfusion of the kidney in reducing delayed graft function after transplantation. The combination of hypothermia and machine perfusion was not superior to machine perfusion alone.

Pulsatile Machine Perfusion



Case scenario

-52 years old male with ESKD sec to DM Type 2
-Renal Tx-Stable graft function. Serum Creatinine 120 umol/L, 5 years post-deceased donor Tx
-Developed CMV Disease early post-Tx and converted from Tacrolimus to Everolimus.
-Currently on Everolimus, Mycophenolate & Prednisolone
-Now has developed triple vessel disease-posted for CABG

- **In managing the patient peri-operatively, the following statement is true:**
  - **Patient is highly likely to require short term dialysis post-operatively**
  - **B. Change from Everolimus to Tacrolimus may be considered**
  - **C. Patient will require Valganciclovir treatment to prevent relapse of CMV infection**
  - **D. The mortality is higher than in patients on dialysis**

Infections Post- Transplant

- CMV
- BKV
- PJP

CMV

- 45 year old male, ESKD sec to DM type 2
- Received DBD kidney 4/6 HLA MM- 6 months ago
- CMV D+/R-
- Valganciclovir withheld/stopped after 2 months due to persistent Leucopenia
- Presents with fever, pneumonitis, diarrhea and graft dysfunction

Collected	CMV Viral Load (IU/mL)	CMV Viral Load (log10)
07/09/2022	7.74E+05	5.89
31/08/2022	1.58E+06	6.20
21/08/2022	3.30E+06	6.52

CMV: Cytomegalo Virus

- **Fever, *Leukopenia*, Pneumonitis, Hepatitis**
- **Anti-Viral Prophylaxis with Valganciclovir**
- **Highest risk: D+/R-**

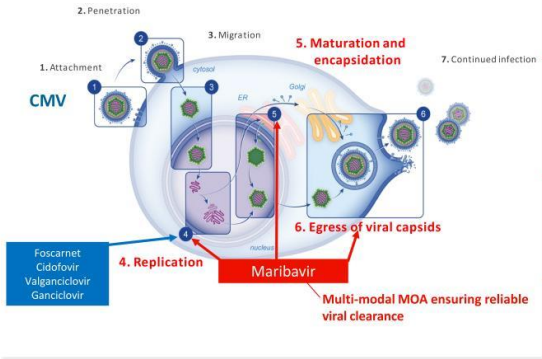
IMPACT Study

- Multicenter, double-blind, randomized controlled trial comparing the efficacy and safety of 200 vs 100 days of valganciclovir prophylaxis (900 mg once daily)
- CMV disease developed in significantly fewer patients in the 200-day group within 12 months posttransplant (16.1% vs 36.8%, $P < .0001$)
- Confirmed CMV viremia was significantly lower in the 200-day group (37.4% vs 50.9%, $P = .015$ at month 12)
- There was no significant difference in the rate of biopsy-proven acute rejection between the groups (11% vs 17%, respectively, $P = .114$)

Gancyclovir resistance

- Cidofovir/ Foscarnet
- CMV Hyperimmune IVIG
- New drug: Maribavir

MARIBAVIR HAS THE POTENTIAL TO REDEFINE SUCCESS IN POST-TRANSPLANT CMV DUE TO ITS NOVEL MULTI-MODAL MECHANISM OF ACTION



Maribavir:

Works at 3 *different* points (4, 5 & 6) in the viral lifecycle: viral DNA replication, maturation & encapsidation

Only agent that targets pUL97 all other agents inhibit *only* viral replication (#4) at pUL54

Novel MOA permits efficacy against drug resistant CMV

BK VIRUS

47 year old male with IgAN- 2nd Renal transplant-

Month 1 post Tx- NODAT/PTDM

Month 3

BK Viruria, BK Viremia

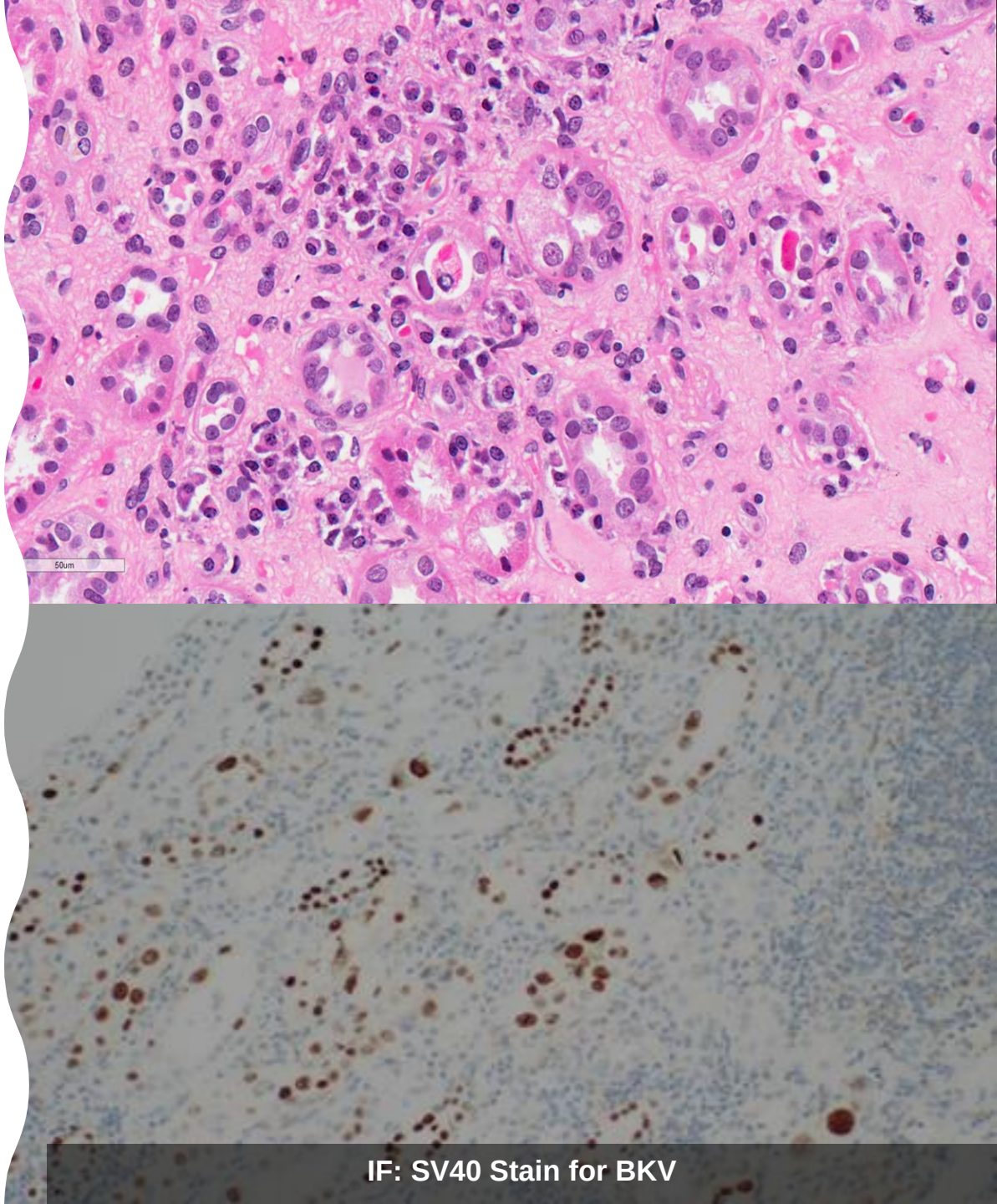
Meds: Tacrolimus 5 mg b.d, Mycophenolate 1 G b.d, and Prednisolone 5mg daily

underwent Tx Bx- BKVN

Viruria->Viremia-> BK Nephropathy

BK Virus Nephropathy

- Tubulo-interstitial Damage mimicking cellular rejection
- Look for viral inclusion bodies
- IF: SV-40 stain



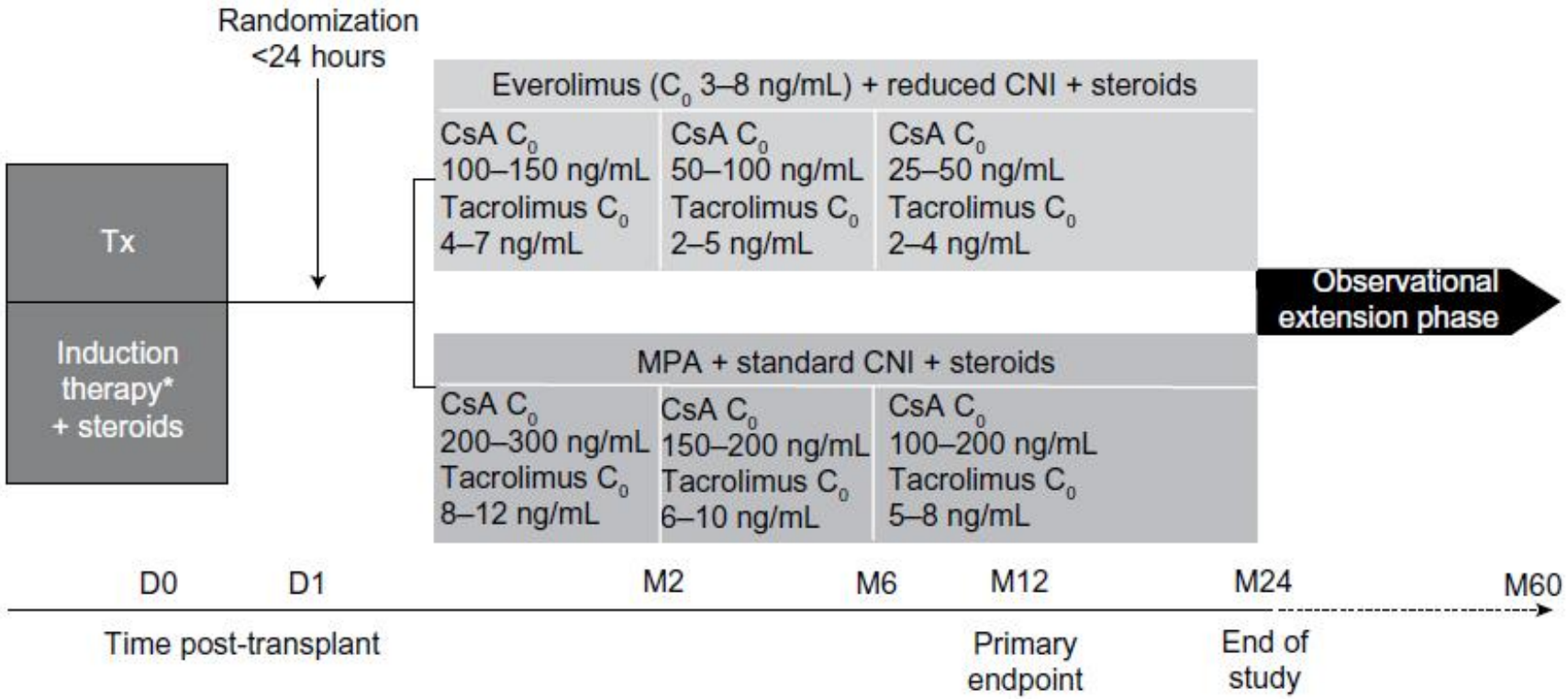
IF: SV40 Stain for BKV

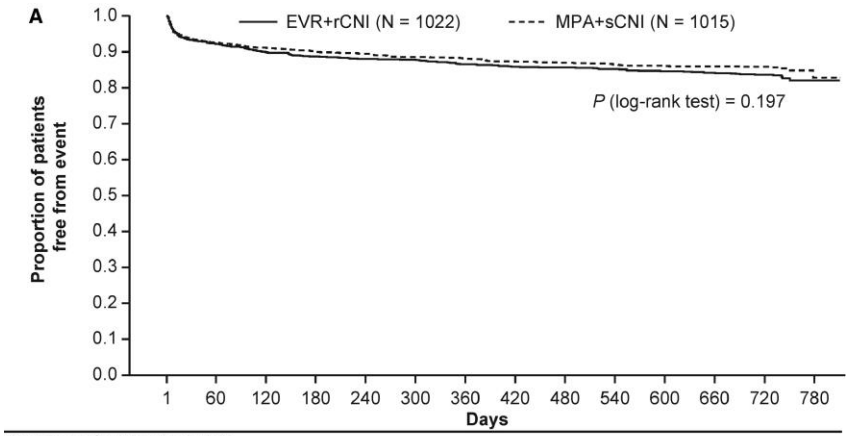
BKVN

In treating BKVN, the following measures are appropriate:

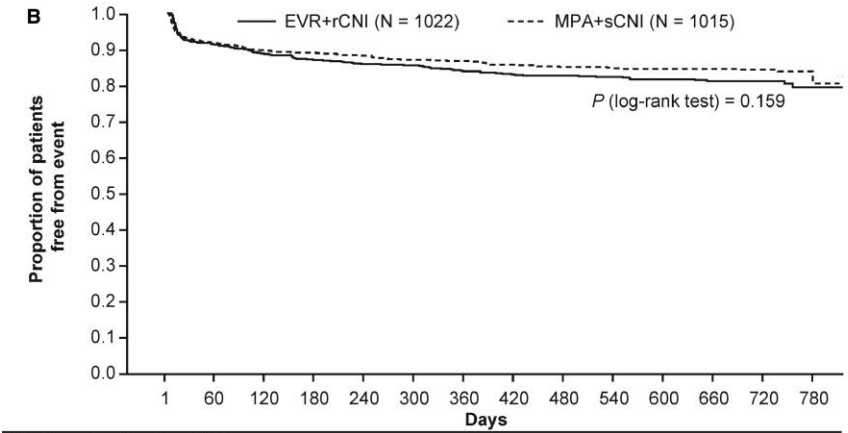
A. Reduce the dose of MMF
B. Reduce the dose of Tacrolimus
C. Treat with Cidofovir
D. All of the above

Transform Trial





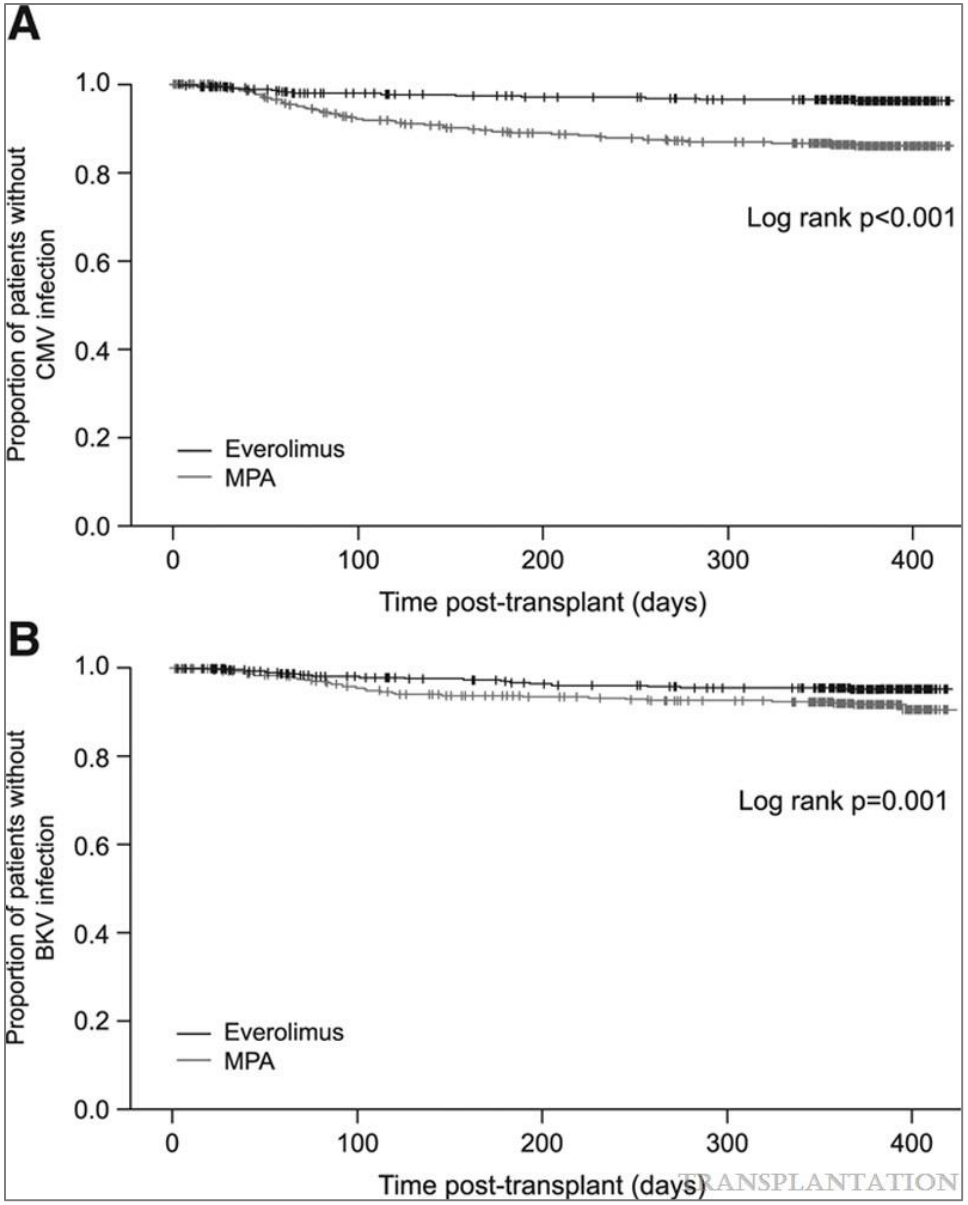
Number of patients at risk														
EVR+rCNI	1022	934	905	890	878	872	858	847	839	832	819	809	672	27
MPA+sCNI	1015	935	914	899	888	875	868	850	842	834	822	814	679	37



Number of patients at risk														
EVR+rCNI	1022	940	911	897	885	876	863	848	839	832	819	809	672	27
MPA+sCNI	1015	941	920	904	893	880	872	853	844	836	825	816	681	38

(A) Composite efficacy failure endpoint of tBPAR, graft loss or death, and
(B) tBPAR (Full Analysis Set– 24-month analysis).

FIGURE 2.

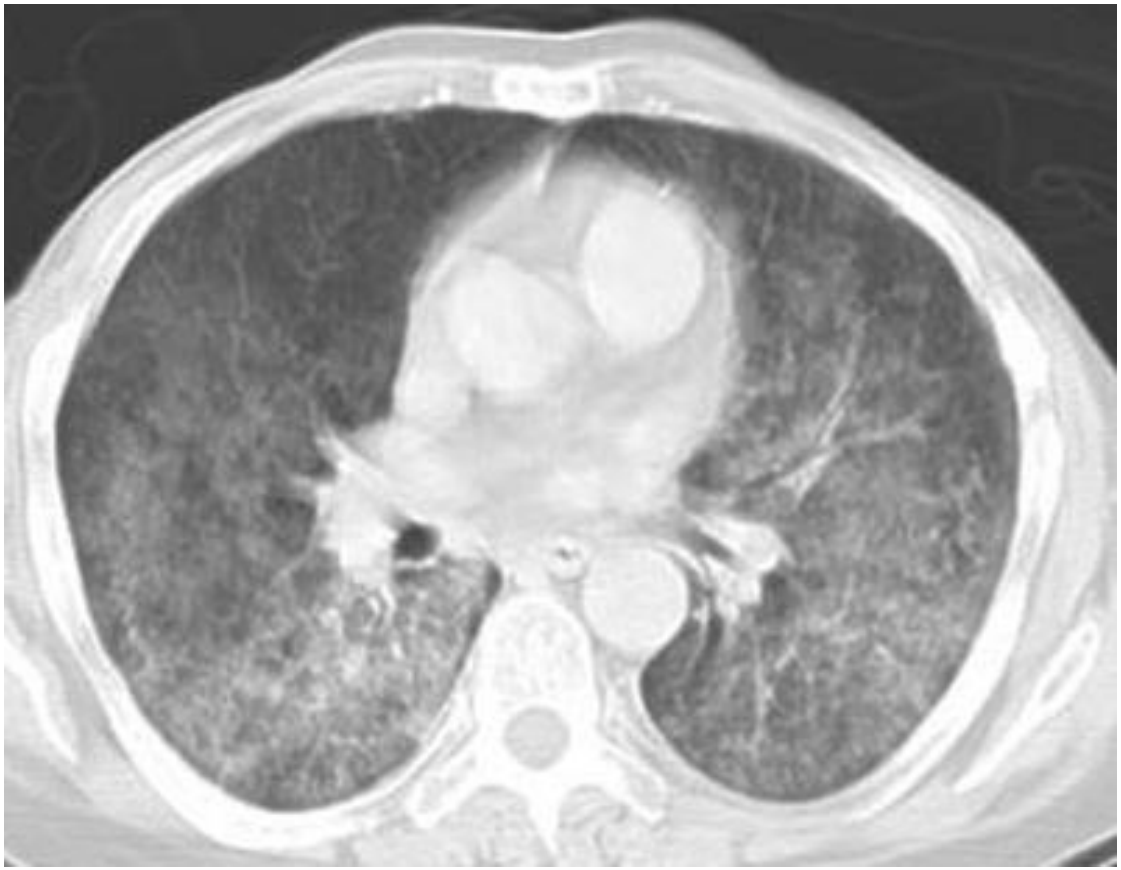


Safety of Everolimus With Reduced Calcineurin Inhibitor Exposure in De Novo Kidney Transplants: An Analysis From the Randomized TRANSFORM Study

Transplantation103(9):1953-1963, September 2019.

Kaplan-Meier plots of time to first event for (A) cytomegalovirus (CMV) infection and (B) BK virus (BKV) infection, according to treatment group (safety population).

MPA, mycophenolic acid.



HR CT Chest

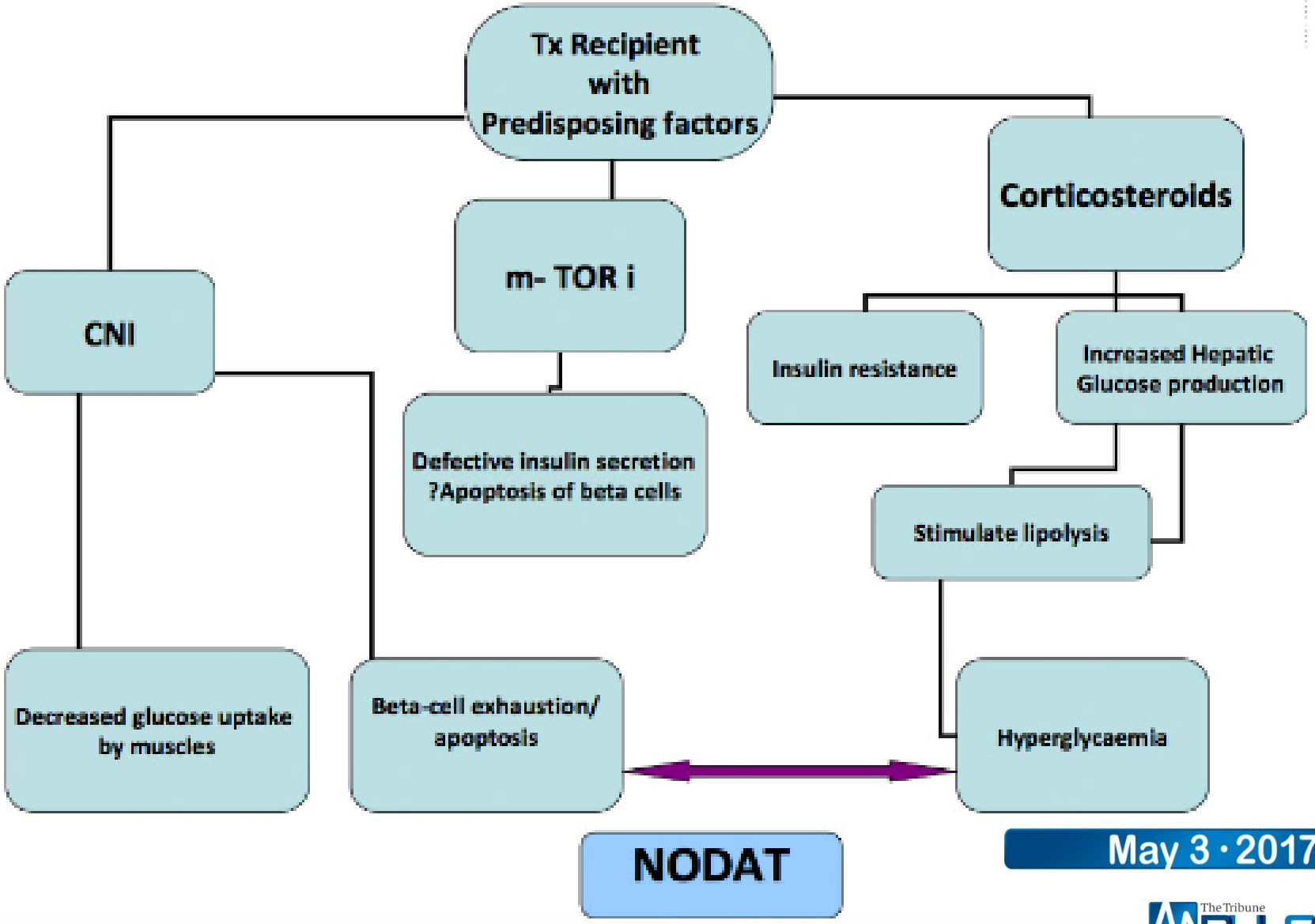
- 57 years old male with IgA N on HD for 3 years.
- Tx 4 months ago
- *Ceased Co-trimoxazole after 1 month due to persistent Leucopenia*
- Presents with Fever, Dry cough, SOB: 1 week

PJP Prophylaxis

- Duration? 6 months.
- Co-trimoxazole/Bactrim DS on alternate days
- Sulfa Allergy: Pentamidine IV/ nebulization

Long Term Complications

- NODAT/ PTDM
- Malignancy



May 3 · 2017
Volume I • Issue 10
The Tribune PULSE
Your Weekly Transplantation Update

Figure 1: Immunosuppressive Medications and NODAT

Skin Cancers

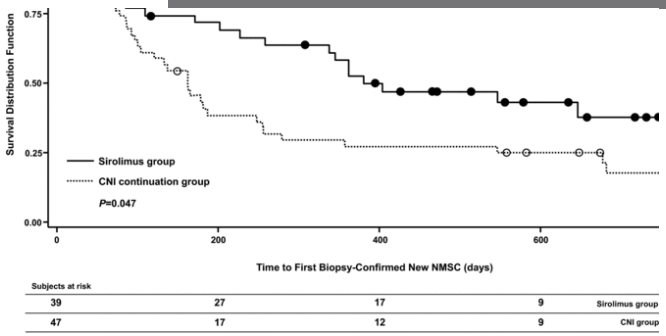
- 7 years post-Tx
- Serum creatinine 130.
- Stable triple immunosuppression: Tacrolimus, Mycophenolate and Prednisolone
- Multiple Squamous Cell Cancers of skin
- Is there evidence for benefit in changing immunosuppression to include mTORi?

Skin cancers and mTORi

Salgo et al, AJT 2010 (10); 1385-1393

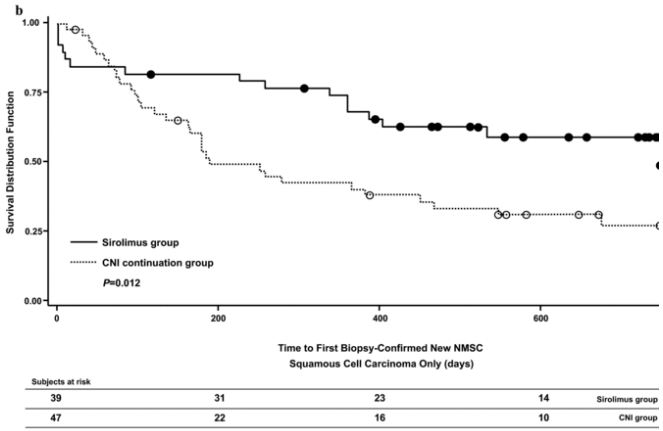
Campbell et al, AJT 2012(12);1146-1156

Randomized Controlled Trial of Sirolimus for Renal Transplant Recipients at High Risk for Nonmelanoma Skin Cancer



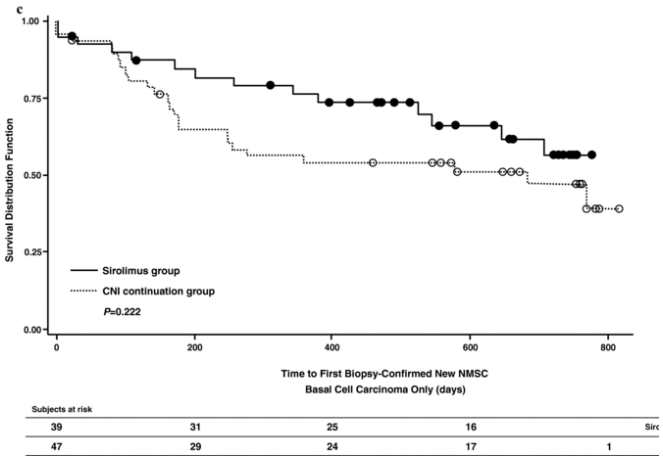
NMSC; p:0.047

NMSC (i.e. SCC or BCC) within 3 years and who underwent kidney transplant at least 1 year before enrolment.



SCC; p:0.012

Yearly NMSC rate was significantly lower with sirolimus (1.31 vs. 2.48 lesions/patient-year; p = 0.022)



BCC; p:0.222

Campbell et al.,
American J Transplantation,2012
Volume: 12, Issue: 5, Pages: 1146-1156

Transplant & Pregnancy

- 29 years old female Tx recipient sec to IgA N who received a deceased donor kidney wishes to conceive.
- Stable renal allograft function for 2 years; current serum creatinine 120. uACR 7.
- On Tacrolimus, Mycophenolate and Prednisolone

The following change in medications is recommended during pregnancy:

- A. Change Tacrolimus to Everolimus
- B. Change Mycophenolate to Azathioprine
- C. Increase the dose of prednisolone to prevent rejection episodes
- D. Routine antibiotic prophylaxis to prevent Urinary Tract infections

Kidney Donation and future pregnancy

- 32 years old male with IgA N in ESKD. Blood Group A Positive
- Married for 3 years, 13 months daughter
- Wife: 29 years old, mother of 13 months old daughter. Blood group O positive
- Blood group compatible with husband
- Enquiring about future risks for the donor in relation to pregnancy

Kidney Donors and Pregnancy

- Kidney donors are at no increased risk of pregnancy associated renal disorders
- Kidney donors have a higher incidence of Gestational HTN/Preeclampsia
- Kidney donors are advised against pregnancy because of high risk of adverse foetal outcomes

Gestational Hypertension and Preeclampsia in Living Kidney Donors

N Engl J Med 2015; 372:124-133

Table 3. Maternal and Fetal Outcomes of Pregnancies after Cohort Entry in Living Kidney Donors and Matched Nondonors.

Outcome	Pregnancies in Donors (N=131)	Pregnancies in Nondonors (N=788)	Odds Ratio (95% CI)	P Value*
	no. of events (%)			
Primary outcome: gestational hypertension or preeclampsia	15 (11)	38 (5)	2.4 (1.2–5.0)	0.01
Secondary outcomes				
Gestational hypertension†	7 (5)	17 (2)	2.5 (0.9–6.5)	0.06
Preeclampsia	8 (6)	21 (3)	2.4 (1.0–5.6)	0.05
Cesarean section	41 (31)	224 (28)	1.2 (0.7–2.1)	0.44
Postpartum hemorrhage	≤5 (≤4)‡	24 (3)	0.9 (0.3–2.9)	0.91
Preterm birth with gestation of <37 wk	10 (8)	52 (7)	1.2 (0.5–2.5)	0.70
Low birth weight of <2500 g	8 (6)	31 (4)	1.7 (0.7–4.0)	0.21

Three years after deceased donor kidney transplantation, a 50-year-old man with end-stage kidney disease (ESKD) sec to DM Type2 is diagnosed with tuberculosis caused by Mycobacterium tuberculosis. He is started on treatment with rifampin and continued on his home immunosuppression, including prednisone, mycophenolate mofetil (MMF), and tacrolimus. Three weeks later, his serum creatinine level increases to 270 mcg/L from a baseline of 90. Urinalysis reveals trace proteinuria, 5 to 10 white blood cells and 0 to 2 red blood cells. He is asymptomatic.

- **What is the most likely cause of acute kidney injury (AKI)?**
  - a) Rifampin-induced AKI due to acute interstitial nephritis
  - b) Rifampin-induced AKI due to acute tubular necrosis
  - c) Allograft rejection
  - d) Allograft pyelonephritis

CNI Drug Interactions

Erythromycin, clarithromycin	Potent inhibition of cytochrome P450 *Alternatives:* Azithromycin is an acceptable alternative in some cases, less impact on drug metabolism
Azole antifungals	Potent inhibition of cytochrome P450
Diltiazem, verapamil	Moderate inhibition of cytochrome P450 *Alternatives:* Nondihydropyridine calcium channel blockers or β-blockers
Protease inhibitors (eg, ritonavir, darunavir, indinavir)	Very potent inhibitors of metabolism *Alternatives:* nucleoside reverse-transcriptase inhibitors, non-nucleoside reverse-transcriptase inhibitors, or integrase inhibitors

Rifampin	Inducer of cytochrome P450
Rifabutin	Inducer of cytochrome P450
Carbamazepine	Inducer of cytochrome P450
Phenobarbital	Inducer of cytochrome P450

Transplantation: Topics covered

- Transplantation vs. Dialysis
- Rejection
- Immunosuppressive Medications
- Complications of RTR :Infections/ NODAT or PTDM
- Malignancy in RTR
- Pregnancy

ABO incompatible Renal Transplants

- Plasma Exchange
- Immunoadsorption Columns
- Rituximab
- Paired Kidney Exchange

- Splenectomy

ABOi Tx

- 52 male ESKD sec to IgAN
- Blood Group B
- Anti-A titre: 32
- DCDD pathway
- Donor Blood Group A;
- HLA 3/6 MM, No DSA,
  HLA Crossmatch negative
- Immunoadsorption Column Rx in tandem with HD to remove

  Anti-A blood group antibodies

How safe is crossing the ABO blood group barrier in kidney transplantation?

CJASN
Clinical Journal of American Society of Nephrology

Meta-analysis

26 single-center studies

ABO incompatible kidney transplants + same center controls

	1 yr graft survival	Infectious cause of death	Antibody mediated rejection	Non-viral infection
ABO Compatible (N=4943)	98%	13%	2%	6%
ABO Incompatible (N=1346)	96%	49%	10%	12%
	p<0.001	p=0.02	p<0.001	p=0.005

Conclusions ABO-incompatible kidney transplant recipients have good outcomes albeit inferior to center-matched ABO-compatible control patients.

Annelies E. de Weerd and Michiel G.H. Betjes. ABO-Incompatible Kidney Transplant Outcomes: A Meta-Analysis. CJASN doi: 10.2215/CJN.00540118

Tx meds causing Leucopenia

- Co-trimoxazole
- Mycophenolate
- Azathioprine
- Valganciclovir
- All of the above