İntraoperatif aneminin ve/veya transfüzyonun postoperative akut böbrek yetmezliğine etkisi

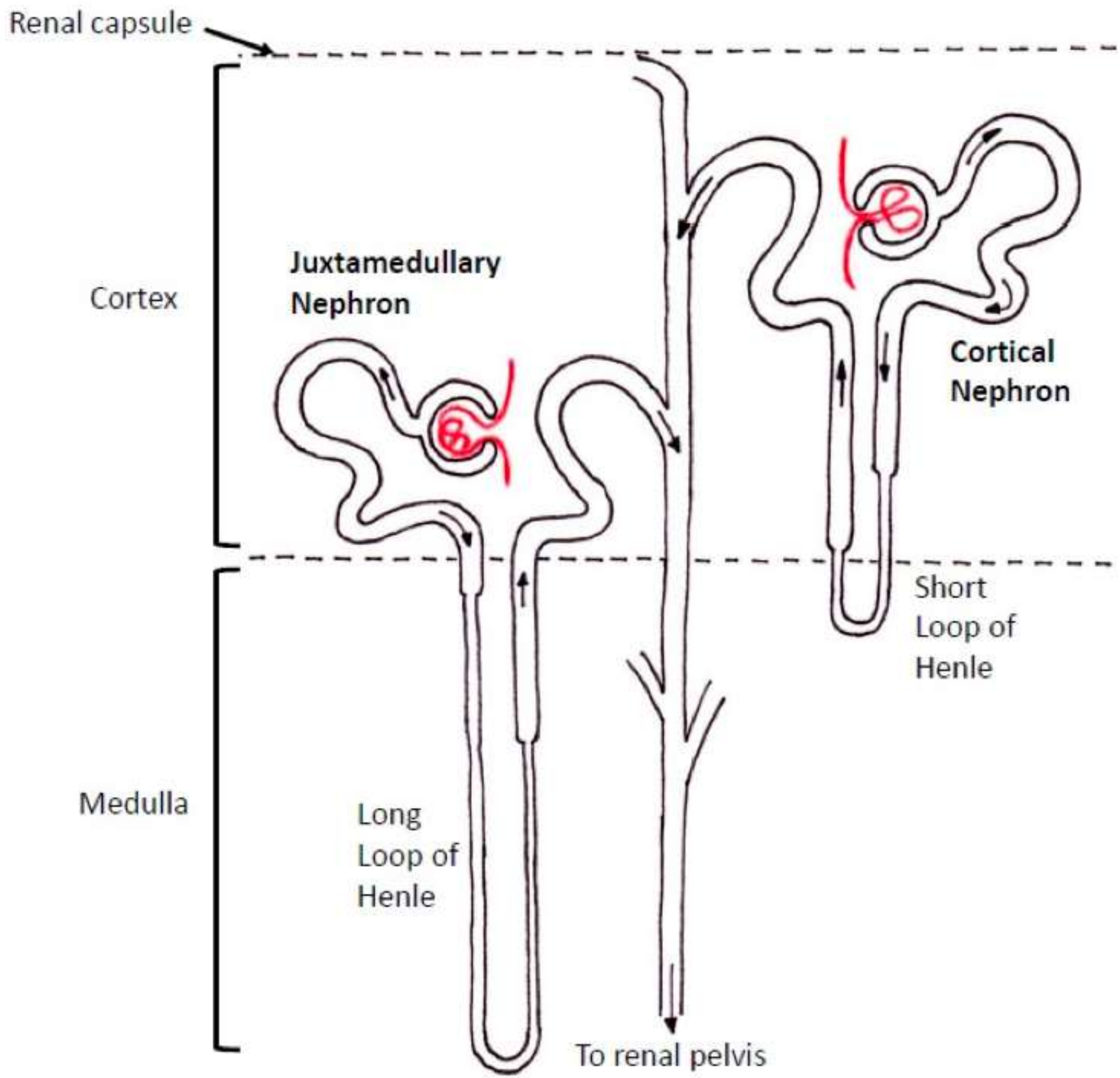
Prof.Dr. Fevzi Toraman

GKDA

2014

Konu Başlıkları

1. Renal fizyoloji
2. EKD’ın renal etkileri
3. Aneminin olumsuz etkileri
4. Transfüzyonun olumsuz etkileri


Renal capsule
Cortex
Juxtamedullary Nephron
Cortical Nephron
Short Loop of Henle
Medulla
Long Loop of Henle
To renal pelvis

RENAL KAN AKIMI (RBF)

- Böbrekler kalp debisinin yaklaşık 1/5 olan 1000 ml/dk kan alırlar
- Bu yaklaşık olarak 300-400 ml /dk/100 gr doku
- Bu miktar;
  - Beynin 6 katı,
  - Kalbin 5 katıdır

Renal Kan Dağılımı

- Korteks kan akımı – 500ml/min/100g
- Dış medulla kan akımı – 100ml/min/100g
- İç medulla kan akımı – 20ml/min/100g

MECHANISMS OF DISEASE

FRANKLIN H. EPSTEIN, M.D., *Editor*

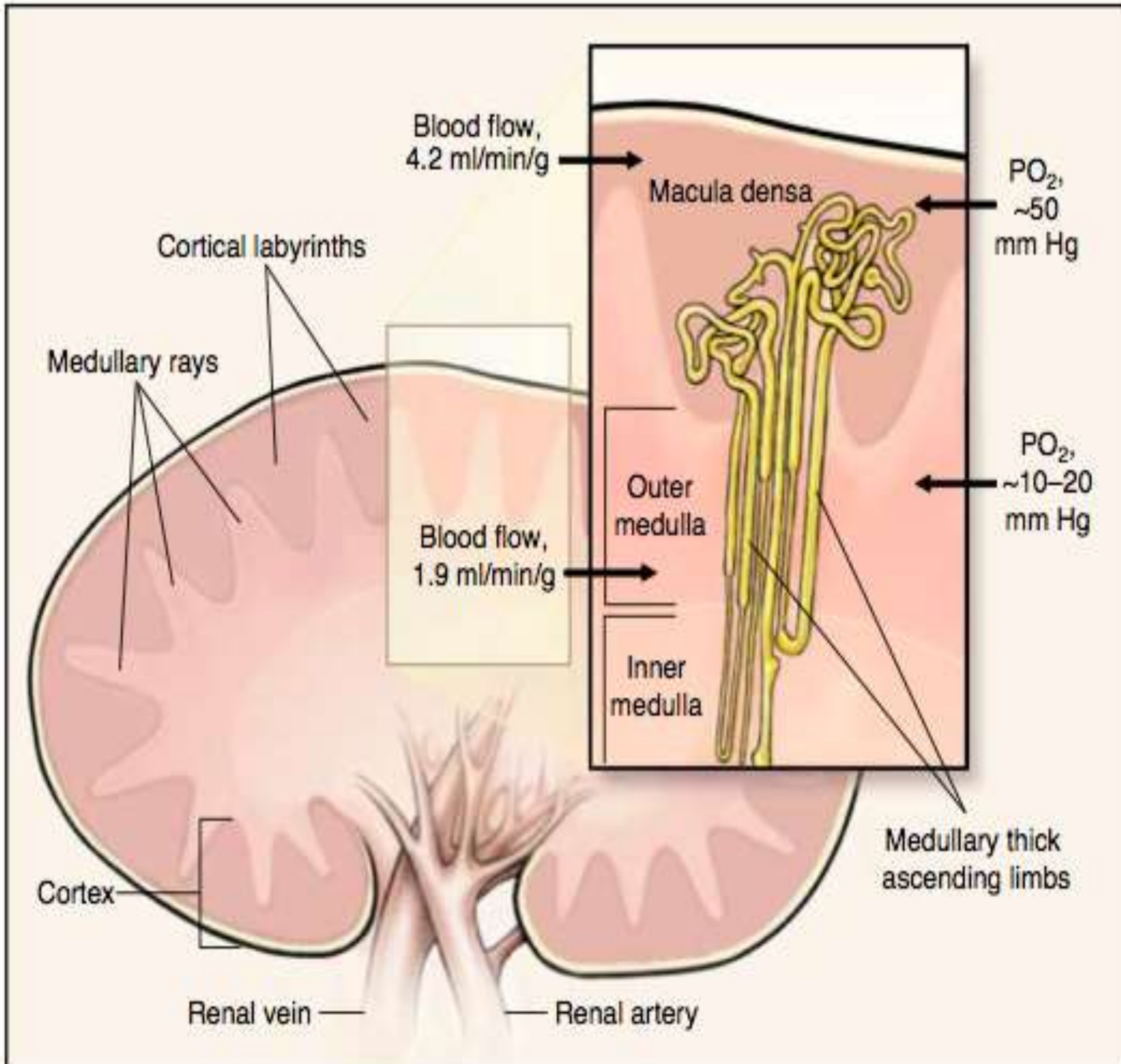
HYPOXIA OF THE RENAL MEDULLA — ITS IMPLICATIONS FOR DISEASE

MAYER BREZIS, M.D., AND SEYMOUR ROSEN, M.D.

IN land mammals, a major task of the kidney is to reabsorb water to allow survival in a dry environment. Water conservation is enhanced by the renal medulla, which concentrates the urine to a level up to four times the osmolality of plasma. To produce this unique gradient of osmolality, the medulla has a countercurrent system of vessels and tubules that dictates active reabsorption of sodium in a milieu poor in oxygen (Fig. 1).[1] In this review, we describe how hypoxia of the medulla may relate to susceptibility to acute and chronic renal injury.

The New England Journal of Medicine 1995;332:647-54

- 1000 ml/dk kanın;
  - %90'ı böbrek korteksine,
  - %10'u medullaya gitmektedir
- Ancak korteksin metabolik aktivitesi çok az olduğundan;
    - Filtrasyon
    - Reabsorbsiyon
  - Korteks kanlanması lüks içinde iken
- Metabolik aktivitesi çok fazla olan medulla
    - Ozmotik gradiyentin korunması ve
    - İdrar konsantrasyonunun artırılması
- Bıçak sırtında aktivitesini sürdürmektedir.



Blood flow,
4.2 ml/min/g
Macula densa
PO2,
~50
mm Hg
Cortical labyrinths
Medullary rays
Outer
medulla
PO2,
~10–20
mm Hg
Blood flow,
1.9 ml/min/g
Inner
medulla
Medullary thick
ascending limbs
Cortex
Renal vein
Renal artery

- Medullar iskemi varlığı bir hastalık belirtisidir.

- Medullar oksijenin temel belirleyicisi Henle kulpunun kalın-uzun çıkan bacağındaki

  Aktif Reabsorbsiyondur

Effects of Extracorporeal Circulation on Renal Function in Coronary Surgical Patients

Guillermo Lema, MD, Gladys Meneses, BSc, Jorge Urzua, MD, Roberto Jalil, MD, Roberto Canessa, MD, Sergio Moran, MD, Manuel J. Irarrazaval, MD, Ricardo Zalaquett, MD, and Pilar Orellana, MD

Departments of Anesthesiology, Nephrology, Cardiovascular Diseases, and Nuclear Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile

We prospectively studied perioperative changes of renal function in 12 previously normal patients (plasma creatinine <1.5 mg/dL) scheduled for elective coronary surgery. Glomerular filtration rate (GFR) and effective renal plasma flow (ERPF) were measured with inulin and ^{125}I-hippuran clearances before induction of anesthesia, before cardiopulmonary bypass (CPB), during hypo- and normothermic CPB, after sternal closure, and 1 h postoperatively. Renal and systemic vascular resistances were calculated. Urinary *N*-acetyl-β-D-glucosaminidase (NAG) and plasma and urine electrolytes were measured, and free water, osmolal, and creatinine clearances, and fractional excretion of sodium and potassium were calculated before and after surgery. ^{125}I-hippuran clearance was lower than normal in all patients before surgery. During hypothermic CPB, ERPF increased significantly (from 261 ± 107 to 413 ± 261 mL/min) and returned toward baseline values during normothermia. GFR was normal before and after surgery and decreased nonsignificantly during CPB. Filtration fraction was above normal before surgery and decreased significantly during CPB (0.38 ± 0.09 to 0.18 ± 0.06). Renal vascular resistance (RVR) was high before surgery and further increased after sternotomy (from 18,086 ± 6849 to 30,070 ± 24,427 dynes · s · cm^{-5}), decreasing during CPB to 13,9647 ± 14,662 dynes · s · cm^{-5}. Urine NAG, creatinine, and free water clearances were normal in all patients both pre- and postoperatively. Osmolal clearance and fractional excretion of sodium increased postoperatively from 1.54 ± 0.06 to 12.47 ± 11.37 mL/min, and from 0.44 ± 0.3 to 6.07 ± 6.27, respectively. We conclude that renal function does not seem to be adversely affected by CPB. Significant functional alterations, such as decreased ERPF and increased RVR, were found before and during surgery, preceding CPB. These periods could contribute to postoperative renal dysfunction.

(Anesth Analg 1995;81:446–51)

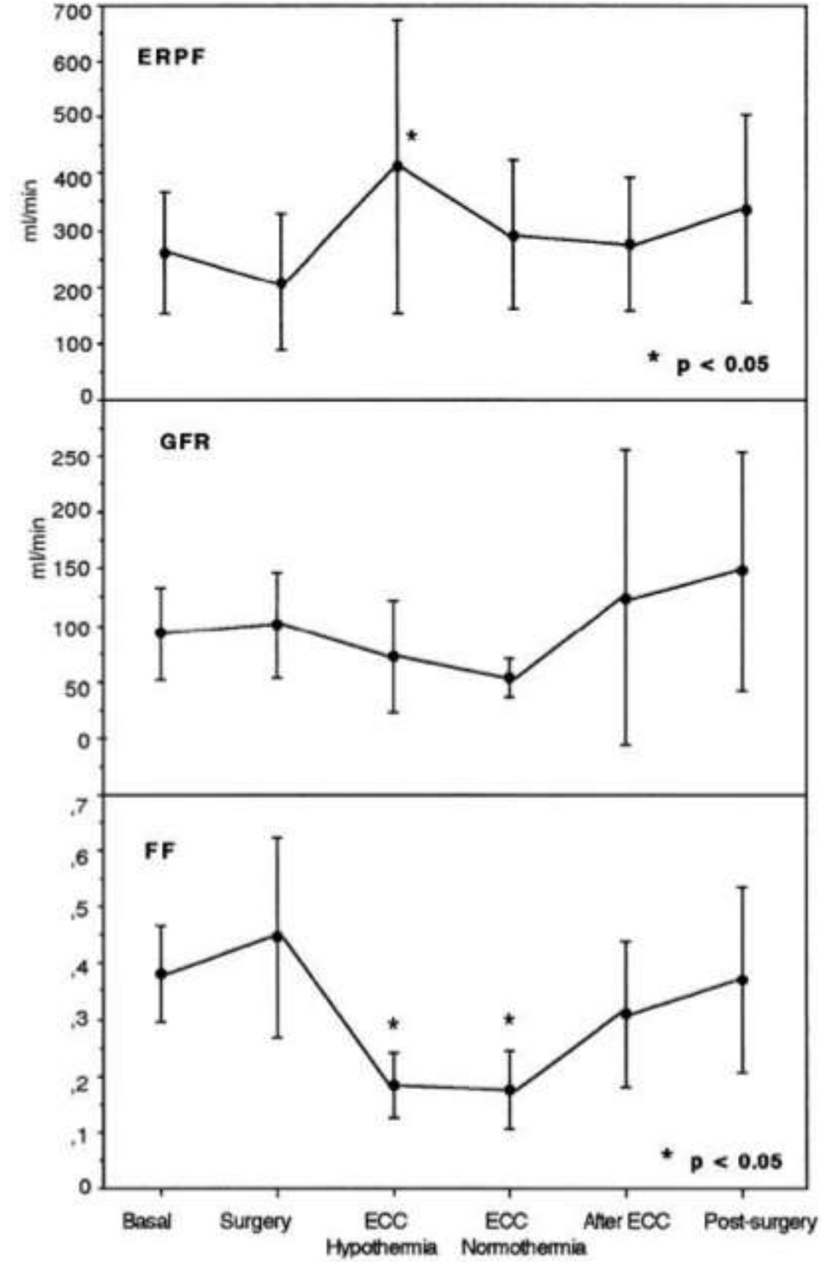


Figure 1. The evolution of effective renal plasma flow (ERPF, top), glomerular filtration rate (GFR, middle), and filtration fraction (FF, bottom). Values shown are mean ± 1 SD. *Significantly different ($P < 0.05$) from baseline.

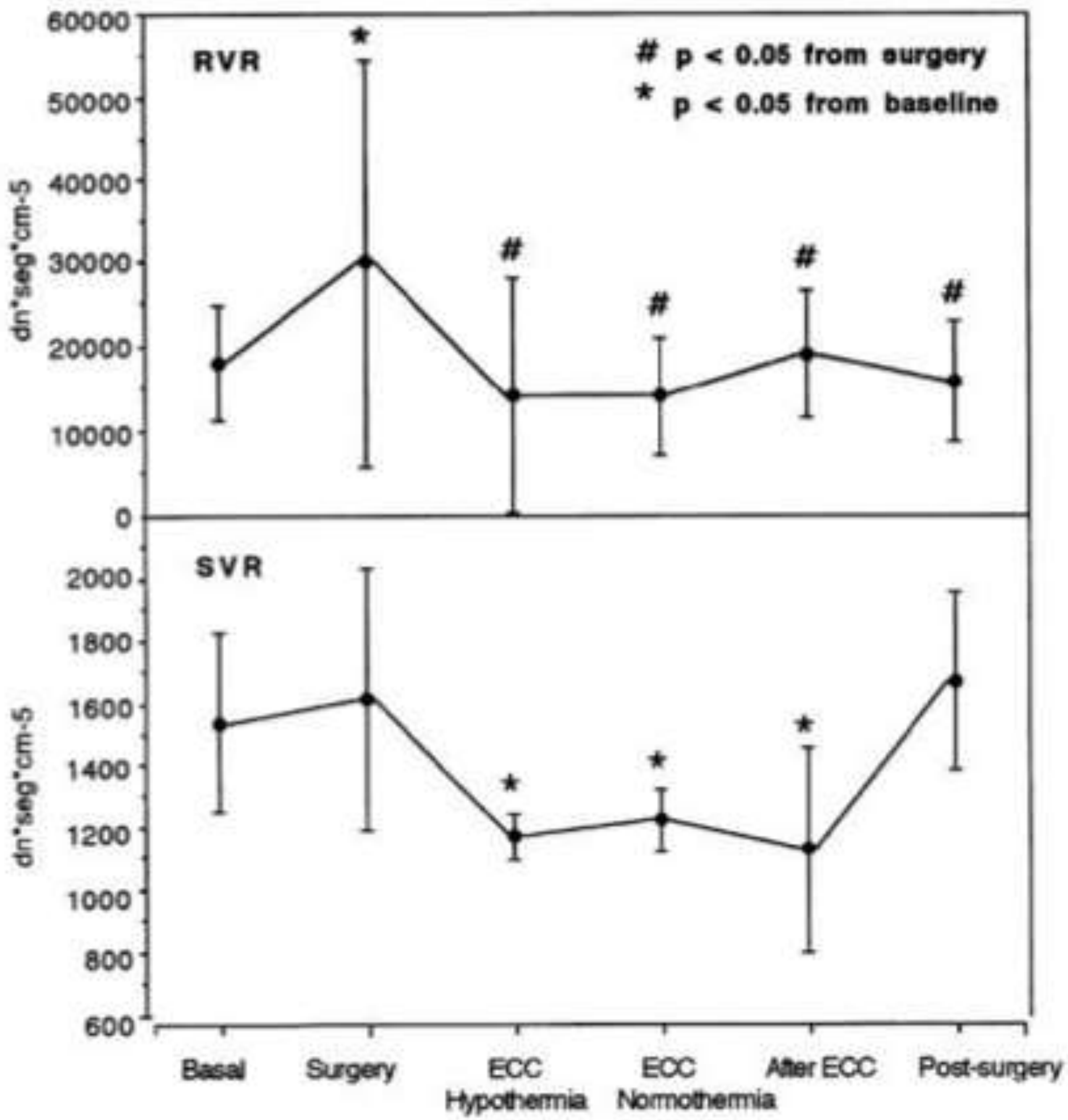


Figure 2. The evolution of renal vascular resistance (RVR, top) and systemic vascular resistance (SVR, bottom). Values shown represent mean ± 1 SD.

Table 2. Comparison of Pre- and Postoperative Plasma and Urine Creatinine and Osmolality, and Osmolal, Creatinine, and Free Water Clearances

	Baseline	Postoperative	*P* value
Plasma creatinine (mg%)	0.86 ± 0.20	0.91 ± 0.18	NS
Urinary creatinine (mg%)	179.2 ± 75.0	13.5 ± 7.1	<0.05
Plasma osmolality (mOsm/L)	287.8 ± 3.7	297.3 ± 5.1	<0.05
Urinary osmolality (mOsm/L)	649.2 ± 110.8	372.8 ± 66.4	<0.05
Creatinine clearance (mL/min)	116 ± 34	120 ± 63	NS
Osmolal clearance (mL/min)	1.54 ± 0.60	12.47 ± 11.37	<0.05
Free water clearance (mL/min)	−0.82 ± 0.25	−1.44 ± 1.97	NS

NS = not significant.

Sonuçlar

1. Tüm hastaların preop RBFdeğeri düşük,
   - Bu durumun stres, açlık ve hipovolemiye bağlı artmış renal ve sistemik vasküler dirençle ilişkili oluğu
2. GFR sadece KPB'ın normotermik döneminde %30 azalma gösterdiğini
   - Aynı dönemdeki FNa itrahındaki azalmanın bunu desteklediğini

J Thorac Cardiovasc Surg 1992;104:1625-7.

Anaesth Intensive Care 1993;21:56-61.

3. Filtration Fraction: GFR / RBF

- Anestezi öncesi
- Sternotomi öncesi
- KPB sonrası

FF:Yüksek

- Bu durumun,
  - Efferent arteriolar VK gösterdiğini ve
  - Bunun renal vasküler dirençteki artışla paralel olduğunu

KPB sırasında

4. RBF artmakta] FF: Normale dönmekte

GFR hafifçe azalmakta

- KPB'a olan bu anormal cevap
  - ✓Viskositedeki azalma
  - ✓Hipotermi
  - ✓Vazodilatasyona bağlı olabileceğini
- Çünkü,
  - KPB sırasında MAP ve buna bağlı kapiller hidrostatik basınç da düşeceğinden, GFR'nin azalacağı için

Sonuç

5. Normal renal fonksiyonlara sahip hastalarda KPB'ın klinik açıdan önemli sayılacak olumsuz etkisinin olmadığı
   - Ancak KPB öncesi, sırası ve sonrası önemli hemodinamik değişikliklerin olduğunu
     - Renal kan akımında azalma
     - RVR de artma
   - Tüm bu hemodinamik değişikliklerin postop renal disfonksiyon gelişmesinde KPB'dan daha etkili olduğunu ifade ediyorlar

The Association of Lowest Hematocrit During Cardiopulmonary Bypass With Acute Renal Injury After Coronary Artery Bypass Surgery

Madhav Swaminathan, MD, Barbara G. Phillips-Bute, PhD, Peter J. Conlon, MD, Peter K. Smith, MD, Mark F. Newman, MD, and Mark Stafford-Smith, FRCPC

Departments of Anesthesiology, Medicine, and Surgery, Duke University Medical Center, Durham, North Carolina

Background. Acute renal injury is a common serious complication of cardiac surgery. Moderate hemodilution is thought to reduce the risk of kidney injury but the current practice of extreme hemodilution (target hematocrit 22% to 24%) during cardiopulmonary bypass (CPB) has been linked to adverse outcomes after cardiac surgery. Therefore we tested the hypothesis that lowest hematocrit during CPB is independently associated with acute renal injury after cardiac surgery.

Methods. Demographic, perioperative, and laboratory data were gathered for 1,404 primary elective coronary bypass surgery patients. Preoperative and daily postoperative creatinine values were measured until hospital discharge per institutional protocol. Stepwise multivariable linear regression analysis was performed to determine whether lowest hematocrit during CPB was independently associated with peak fractional change in creatinine (defined as the difference between the preoperative and peak postoperative creatinine represented as a percentage of the preoperative value). A p value of less than 0.05 was considered significant.

Results. Multivariable analyses including preoperative hematocrit and other perioperative variables revealed that lowest hematocrit during CPB demonstrated a significant interaction with body weight and was highly associated with peak fractional change in serum creatinine (parameter estimate [PE] = 4.5; $p = 0.008$) and also with highest postoperative creatinine value (PE = 0.06; $p = 0.004$). Although other renal risk factors were significant covariates in both models, TM50 (an index of hypotension during CPB) was notably absent.

Conclusions. These results add to concerns that current CPB management guidelines accepting extreme hemodilution may contribute to postoperative acute renal and other organ injury after cardiac surgery.

(Ann Thorac Surg 2003;76:784–92)

Table 2. Hematocrit, Hemodynamic, and Creatinine Data

Variable	Mean (SD)	Range
Preoperative Hct (%)	40.1 (9.1)	22–52
Lowest Hct during bypass (%)	19.5 (3.8)	10–33
TM50 (mm Hg · min)	135.9 (139.7)	−1042–0
CrPre (mg/dL)	1.1 (0.5)	0.5–4.9
Cr_{max}Post (mg/dL)	1.41 (0.7)	0.5–8.2
%ΔCr (%)	26.6 (45.0)	−74.4–722.2
CrClPre (mL/min)	80.9 (33.4)	10.5–254.7
CrClPost (mL/min)	67.2 (28.8)	10.2–212.3

CrClPost = lowest postoperative creatinine clearance; CrClPre = preoperative creatinine clearance; Cr_{max}Post = peak postoperative creatinine; CrPre = preoperative creatinine; Hct = hematocrit; %ΔCr = peak postoperative fractional change in creatinine; TM50 = integral of time and mean arterial pressure less than 50 mm Hg during cardiopulmonary bypass.

Table 3. Multivariable Linear Regression Analysis of Factors Associated With Peak Postoperative Change in Creatinine

Variable	Parameter Estimate	95% Confidence Limits		*p* Value
Intercept	−59.0	−126.0	8.1	0.08
Lowest Hct during bypass (%)	4.5	1.2	7.8	0.008
CrPre (mg/dL)	−15.0	−20.7	−9.3	<0.0001
Charlson comorbidity score	3.5	0.9	6.2	0.009
Body weight (kg)	1.3	0.5	2.1	0.001
Lowest Hct during bypass*weight	−0.05	−0.1	−0.01	0.007
Preoperative Hct (%)	−0.6	−1.0	−0.2	0.008
IABP use	31.3	4.6	57.9	0.02
RBC 48 hours (units)	2.3	0.6	4.0	0.009
Inotrope use[a]	7.8	1.7	13.9	0.01
Prebypass serum glucose (mg/dL)	0.07	0.02	0.1	0.01
TM50 (mm Hg · min)	−0.00	−0.02	0.01	0.64

[a] Inotrope use defined as postoperative infusion of either dopamine > 5 $\mu g \cdot kg^{-1} \cdot min^{-1}$ or dobutamine > 5 $\mu g \cdot kg^{-1} \cdot min^{-1}$, or both, or epinephrine > 0.03 $\mu g \cdot kg^{-1} \cdot min^{-1}$.

$Cr_{max}Post$ = peak postoperative serum creatinine; CrPre = preoperative serum creatinine; Hct = hematocrit; IABP = intraaortic balloon pump; RBC 48 hours = number of units of packed red cells given within the first 48 hours postoperatively.

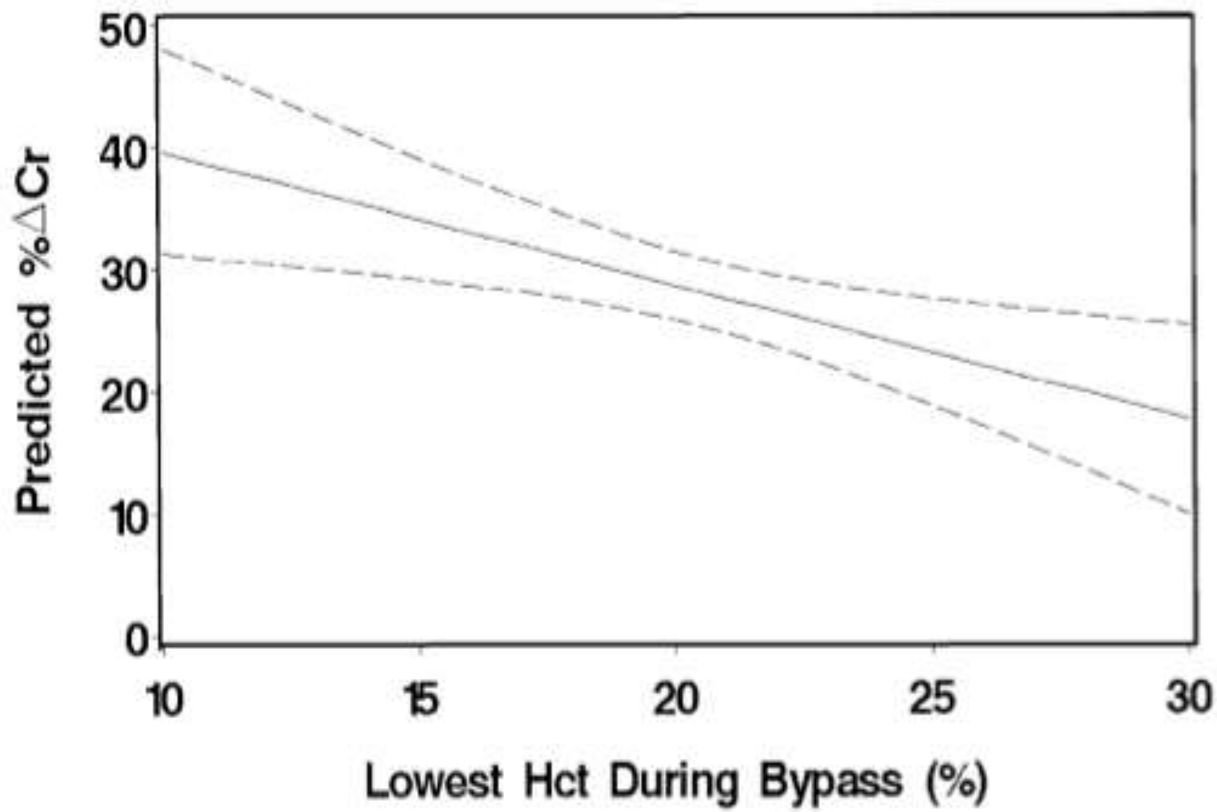


Fig 2. The relationship of lowest hematocrit (Hct) *during bypass to peak percentage change in creatinine* (%ΔCr) *in patients (n = 776) with weight 75 kilos or more, with 95% confidence limits* (dashed lines). *The regression equation is* $\%\Delta Cr = 50.62 + (\text{lowest Hct during bypass}^* -1.10)$.

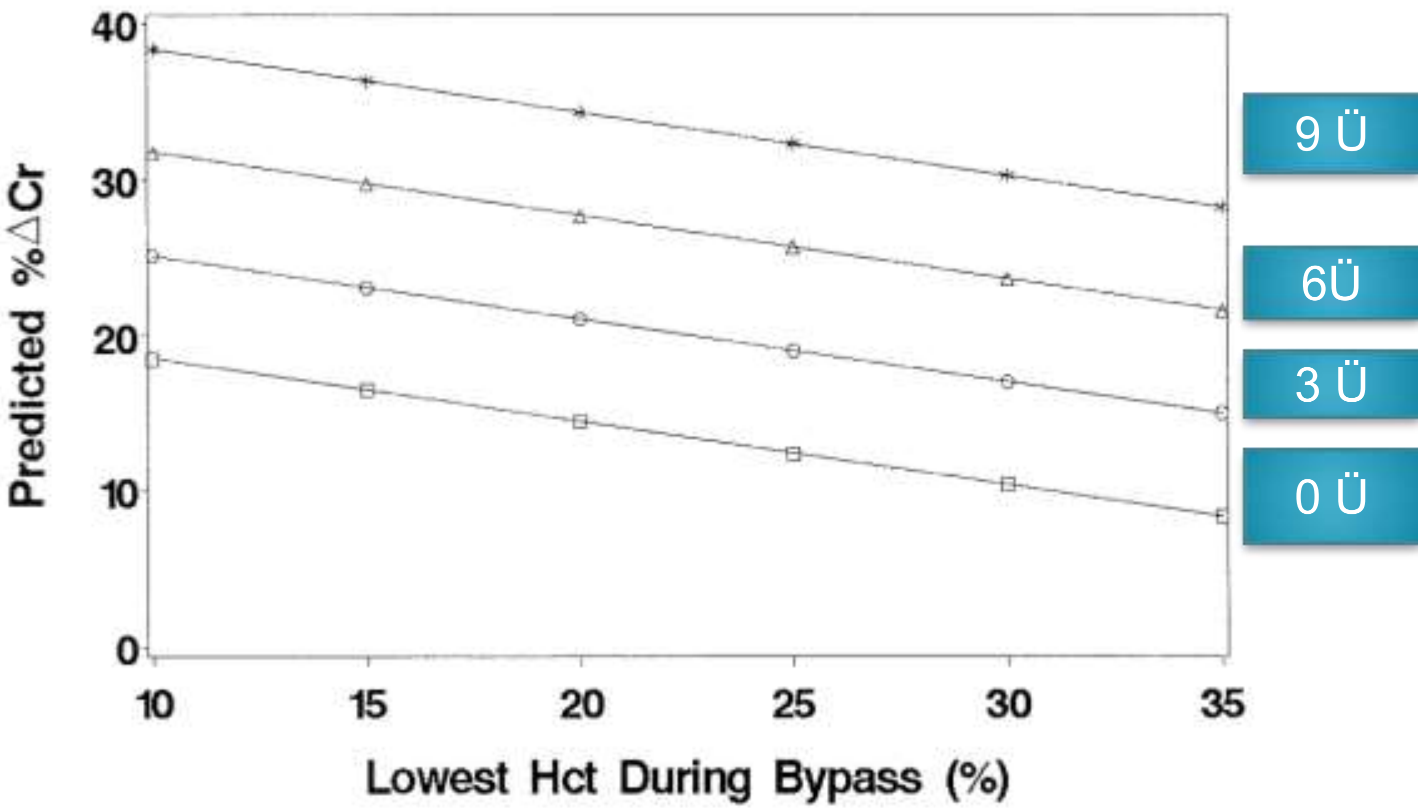


Fig 4. The influence of blood transfusion on the relationship between lowest hematocrit (Hct) *during cardiopulmonary bypass and peak postoperative fractional change in creatinine* (%ΔCr). *RBCs: 9* (asterisks); *6* (triangles); *3* (circles); *0* (squares). *(RBCs = number of units of packed red blood cells transfused intraoperatively.)*

Role of hemodilutional anemia and transfusion during cardiopulmonary bypass in renal injury after coronary revascularization: Implications on operative outcome*

Robert H. Habib, PhD; Anoar Zacharias, MD; Thomas A. Schwann, MD; Christopher J. Riordan, MD; Milo Engoren, MD; Samuel J. Durham, MD; Aamir Shah, MD

Objective: Acute renal injury and failure (ARF) after cardiopulmonary bypass (CPB) has been linked to low on-pump hematocrit (hematocrit). We aimed to 1) elucidate if and how this relation is modulated by the duration of CPB (T_{CPB}) and on-pump packed red blood cell transfusions and 2) to quantify the impact of post-CPB renal injury on operational outcome and resource utilization.

Design: Retrospective review.

Setting: A Northwest Ohio community hospital.

Patients: Adult coronary artery bypass surgery patients with CPB but no preoperative renal failure.

Interventions: None.

Measurements and Main Results: We quantified post-CPB renal injury via 1) the peak postoperative change in serum creatinine (Cr) level relative to pre-CPB values (%ΔCr) and 2) ARF, defined as the coincidence of post-CPB Cr ≥2.1 mg/dL and >2 times pre-CPB Cr. The separate effects of lowest hematocrit, intraoperative packed RBC transfusions, and T_{CPB} on %ΔCr and ARF were derived via multivariate regression, overlapping quintile subgroup analyses, and propensity matching. Lowest hematocrit (22.0% ± 4.6% SD), T_{CPB} (94 ± 35 mins), and pre-CPB Cr (1.01 ± 0.23 mg/dL) varied widely. %ΔCr varied substantially (24 ± 57%), and ARF was documented in 89 patients (5.1%). Both %ΔCr ($p < .001$) and ARF ($p < .001$) exhibited sigmoidal dose-dependent associations to lowest hematocrit that were 1) modulated by T_{CPB} such that the renal injury was exacerbated as T_{CPB} increased, 2) worse in patients with relatively elevated pre-CPB Cr (≥1.2 mg/dL), and 3) worse with intraoperative packed red blood cell transfusions (n = 385; 21.9%), in comparison with patients at similar lowest hematocrit. Operative mortality ($p < .01$) and hospital stays ($p < .001$) were increased systematically and significantly as a function of increased post-CPB renal injury.

Conclusions: CPB hemodilution to hematocrit <24% is associated with a systematically increased likelihood of renal injury (including ARF) and consequently worse operative outcomes. This effect is exacerbated when CPB is prolonged with intraoperative packed red blood cell transfusions and in patients with borderline renal function. Our data add to the concerns regarding the safety of currently accepted CPB practice guidelines. (Crit Care Med 2005; 33:1749–1756)

Key Words: cardiac surgery; renal failure; creatinine; operative mortality; prime fluid; hematocrit; propensity analysis

Table 1. Comparison of selected patient, operative, and outcome data for coronary artery bypass grafting (CABG) groups with and without renal injury

Variable	No RI n/Mean ± SD	%	RI[a] n/Mean ± SD	%	*p* Value	ARF n/Mean ± SD	%	*p* Value vs. No RI	*p* Value vs. RI[b]
Demographic/risk factor									
No. of patients	1475		285			89			
Women	451	*31*	103	*36*	.064	40	*45*	.005	.037
Age, yrs	63 ± 10		66 ± 10		.000	67 ± 10		.001	.219
Body mass index (kg/m^2)	29 ± 5		31 ± 6		.000	32 ± 7		.000	.075
Morbid obesity	209	*14*	77	*27*	.000	28	*32*	.000	.256
Diabetes	473	*32*	127	*45*	.000	49	*55*	.000	.016
Hypertension	1118	*76*	246	*86*	.000	79	*89*	.005	.419
Peripheral vascular disease	233	*16*	65	*23*	.004	22	*25*	.027	.605
Myocardial infarction	878	*60*	186	*65*	.070	60	*67*	.140	.608
Congestive heart failure	152	*10*	52	*18*	.000	18	*20*	.004	.561
Low ejection fraction (<40)	341	*23*	95	*33*	.000	41	*46*	.000	.002
Triple vessel disease	1099	*75*	235	*83*	.004	73	*82*	.112	.897
Catheterization to surgery, days[c]	3 (1–9)		3 (1–10)		.956	4 (1–15)		.050[d]	.152
Operative variables									
Pre-CPB Cr (mg/dL)	1.01 ± 0.22		1.04 ± 0.28		.030	1.16 ± 0.25		.000	.000
Pre-CPB Cr-clearance (men)	95 ± 30		97 ± 39		.443	88 ± 33		.114	.059
Pre-CPB Cr-clearance (women)	80 ± 30		86 ± 42		.071	74 ± 44		.223	.014
Redo surgery	61	*4.1*	32	*11*	.000	9	*10*	.008	.688
Time on CPB (min)	92 ± 32		105 ± 46		.000	100 ± 41		.034	.199
Pre-CPB Hct (%)	39.7 ± 5.1		38.0 ± 5.5		.000	37.2 ± 5.6		.000	.119
Lowest Hct (%)	22.2 ± 4.6		21.3 ± 4.7		.004	20.6 ± 4.1		.001	.077
Post-CPB Hct (%)	24.1 ± 4.9		23.6 ± 4.8		.122	23.2 ± 4.4		.072	.274
Intraop RBC transfusion	292	*20*	93	*33*	.000	33	*37*	.000	.281
Renal function variables									
Post-CPB Cr (high; mg/dL)	1.09 ± 0.30		2.15 ± 1.03		.000	3.16 ± 1.20		.000	.000
Post-CPB Cr-clearance (men)	90 ± 31		53 ± 25		.000	33 ± 14		.000	.000
Post-CPB Cr-clearance (women)	75 ± 29		44 ± 24		.000	27 ± 13		.000	.000
%ΔCr	8 ± 18		108 ± 100		.000	186 ± 149		.000	.000
%ΔCr-clearance	−5 ± 17		−47 ± 12		.000	−61 ± 10		.000	.000
Outcomes									
Intraaortic balloon pump	150	*10*	43	*15*	.015	16	*18*	.020	.359
Postop RBC transfusion	376	*26*	154	*54*	.000	62	*70*	.000	.000
Operative mortality	8	*0.5*	17	*6.0*	.000	10	*11*	.000	.011
30-day readmission	152	*10*	45	*16*	.007	10	*11*	.780	.156
Postop LOS (days)	5.9 ± 4.3		9.3 ± 7.4		.000	12.2 ± 9.2		.000	.000

RI, renal injury, defined as peak postoperative change in serum creatinine (%ΔCr, >50%); ARF, acute renal failure; CPB, cardiopulmonary bypass; Hct, hematocrit; Cr, creatinine; RBC, red blood cell; Postop, postoperative; LOS, length of stay.

[a]Renal injury includes 89 ARF patients; [b]ARF (n = 89), compared with RI patients (n = 196) who did not progress to ARF; [c]catheterization-to-surgery data are given as median (25th to 75th percentiles); [d]median test with Yates correction.

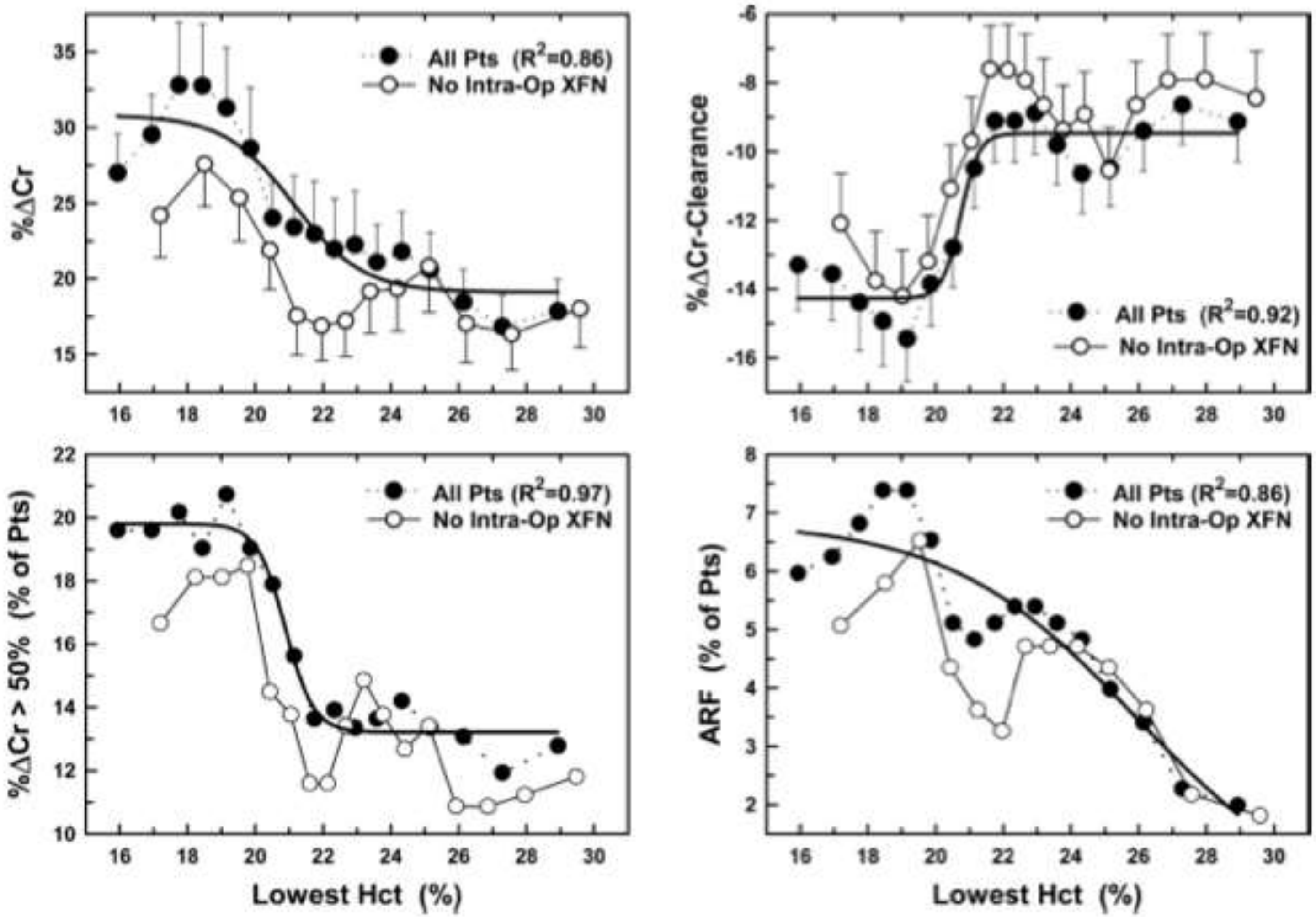
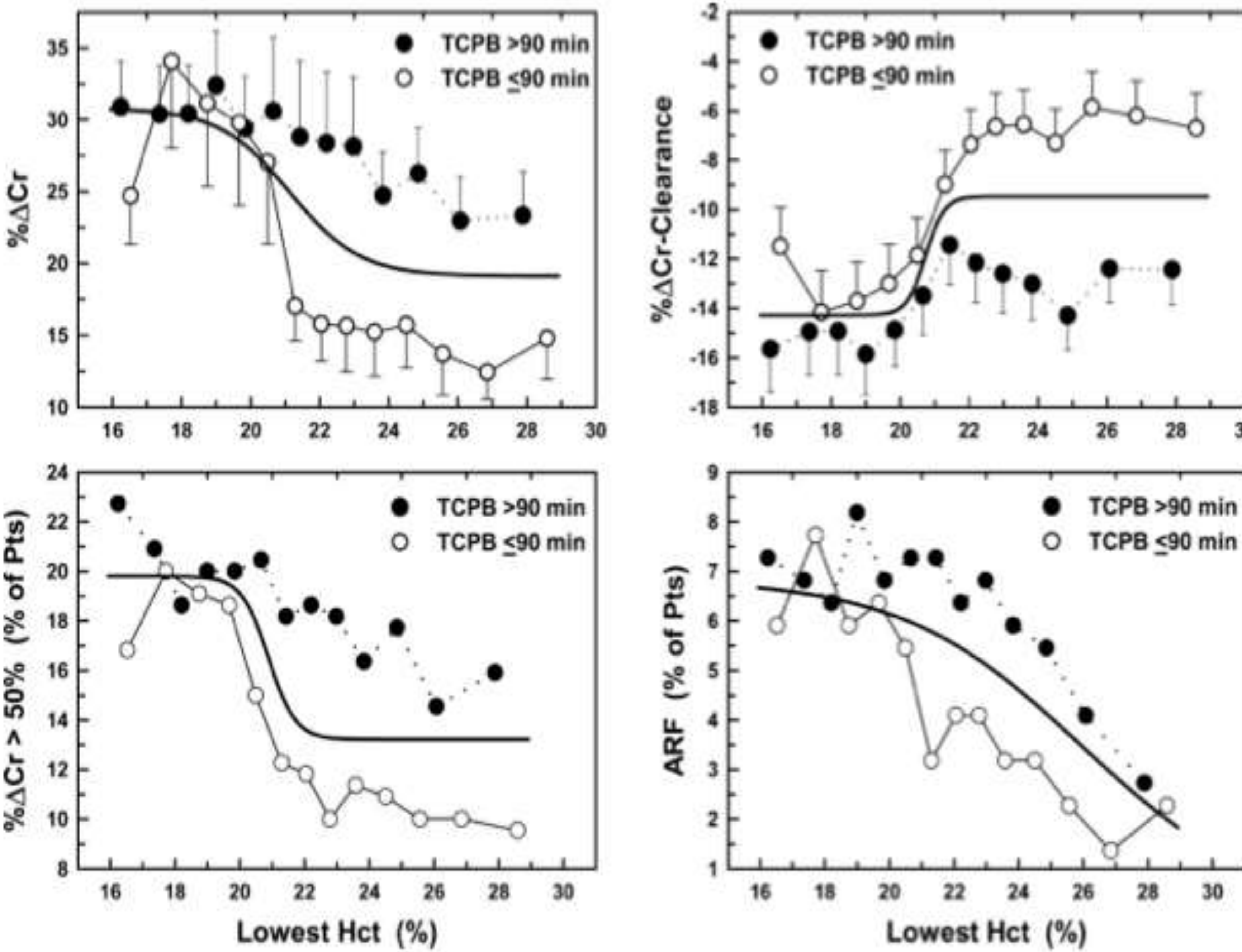


Figure 1. Peak postoperative change in serum creatinine (Cr) level (*%ΔCr*) (*top left*), %ΔCr-clearance (*top right*), renal injury (%ΔCr >50%; *bottom left*), and acute renal injury and failure (*ARF*) (*bottom right*) were all systematically and significantly changed ($p < .001$) as a function of increasing lowest hematocrit (*Hct*) values (16%–31%) determined from overlapping quintile groups. Similar but attenuated relations were derived when 385 recipients of early packed red blood cell transfusions were excluded (*No Intra-Op XFN*). Lines through *All Pts* (patients) data represent sigmoidal model fits to delineate the association for visual clarity. *Error bars* represent standard errors.



TCPB >90 min
TCPB ≤90 min
%ΔCr
%ΔCr-Clearance
%ΔCr > 50% (% of Pts)
ARF (% of Pts)
Lowest Hct (%)
Lowest Hct (%)

Table 3. Multivariate predictors of new-onset post-cardiopulmonary bypass (CPB) acute renal failure (ARF) by logistic regression, with lowest hematocrit considered a continuous and categorical variable

Variable	Wald	*p* Value	Exp(B)	95% Confidence Limits	
				Lower	Upper
Continuous					
Age (per yr)	4.660	.031	1.028	1.003	1.054
Diabetes	9.503	.002	2.040	1.297	3.211
Morbid obesity	20.275	.000	3.271	1.953	5.480
Ejection fraction <40%	16.137	.000	2.534	1.610	3.988
Pre-CPB creatinine	25.083	.000	7.989	3.542	18.016
Lowest hematocrit, %	7.311	.007	.929	.881	.980
Categorical					
Age (per yr)	4.657	.031	1.028	1.003	1.054
Diabetes	9.614	.002	2.049	1.302	3.224
Morbid obesity	20.444	.000	3.298	1.966	5.533
Ejection fraction <40%	15.737	.000	2.504	1.591	3.942
Pre-CPB creatinine	25.316	.000	8.079	3.580	18.23
Lowest hematocrit (%)	8.151	.017			
>24%		Ref.	1.000		
20%–24%	3.185	.074	1.801	.944	3.435
<20%	8.100	.004	2.457	1.323	4.563

Preoperative and intraoperative variables listed in Table 1 were considered for model inclusion.

Hosmer and Lemeshow goodness-of-fit test results: $\chi^2 = 7.423$ ($p = 0.492$) for lowest hematocrit (continuous) and $\chi^2 = 9.216$ ($p = .324$) for lowest hematocrit (categorical).

Table 4. Comparison of propensity-matched coronary artery bypass grafting patients (all with lowest hematocrit <24%) grouped to those receiving versus not receiving intraoperative packed red blood cell (RBC) transfusions

	Intraoperative Transfusion		
	No (n = 208) %/Mean ± SD	Yes (n = 208) %/Mean ± SD	*p* Value
Variable			
Female	51.0	54.3	.4920
Age (yrs)	68 ± 9	67 ± 10	.4016
BSA (m^2)	1.89 ± 0.20	1.91 ± 0.22	.6164
Morbid obesity	10.6	13.0	.4480
Diabetes	37.0	36.5	.9190
Hypertension	81.7	85.6	.2890
Chronic obstructive pulmonary disease	25.5	25.0	.9100
Peripheral vascular disease	25.0	23.6	.7320
Myocardial infarction	65.4	63.0	.6100
Congestive heart failure	16.8	16.3	.8950
Three-vessel disease	76.4	78.4	.6400
Ejection fraction (%)	48 ± 11	48 ± 13	.6370
Operative data			
Reoperation	5.8	5.8	.0000
Emergent	8.7	8.2	.8600
Cross-clamp time (min)	56 ± 23	54 ± 23	.4811
Time on CPB (min)	101 ± 35	98 ± 38	.4151
Pre-CPB Cr (mg/dL)	1.02 ± 0.27	1.03 ± 0.28	.9858
Pre-CPB Cr-clearance	75 ± 25	76 ± 28	.5560
Pre-CPB Hct (%)	36.4 ± 3.9	36.0 ± 4.8	.4390
Lowest Hct (%)	18.6 ± 2.5	18.3 ± 2.8	.2270
Outcome			
Post-CPB Hct (%)	20.1 ± 3.0	21.7 ± 3.6	.0000
Postop RBC transfusion	47.1	57.7	.0310
Intraaortic balloon pump	15.9	14.9	.7860
Post-CPB Cr (high; mg/dL)	1.23 ± 0.52	1.47 ± 1.00	.0020
%ΔCr	21 ± 38	45 ± 111	.0029
Post-CPB Cr-clearance	65 ± 23	61 ± 25	.0910
%ΔCr-Clearance	−11 ± 23	−18 ± 26	.0043
Renal injury	14.4	26.0	.0030
ARF	3.4	12.0	.0010
Postop LOS	6.3 ± 3.8	8.1 ± 7.4	.0027
30-day readmission	12.0	13.9	.5600
Operative mortality	1.4	3.8	.1270

BSA, body surface area; CPB, cardiopulmonary bypass; Cr, creatinine; Hct, hematocrit; LOS, length of stay.

Sonuçlar

1. ARY olmaksızın postop kreatinin yükselmesi
   - Kaynak kullanımını
   - Mortaliteyi artırmaktadır
2. KPB sonrası renal fonksiyon bozukluğu için,
   - Düşük Hct ve
   - Uzayan pompa süresi gerekli değil

- Ancak bu parametrelerin varlığı olasılığı artırmaktadır

Sonuçlar

3. KPB sırasındaki dilüsyonel aneminin derecesi ile renal fonksiyon bozukluğu arasında SİGMOİDAL bir ilişki var

  - Bu sigmoidal ilişkide, kırılma noktası en düşük Hct değeri %24'de başlamakta

Sonuçlar

4. Benzer seviyede düşük Hct değerine sahip hastalara RBC transfüzyonu yapıldığında ,
   - Transfüzyon grubunda,
     - ARY
     - Postop kreatinin yükselmesi olasılığı daha da artmaktadır (propensity macthed)

Sonuçlar

5. Düşük Hct (<%24) kısa süre başarı ile tolere edilebilir

- Fakat,
  - Orta derecede düşük Hct (>%24)
  - Uzayan KPB zamanı ile birlikte olursa,
  - Renal fonksiyon bozukluğu olasılığı artmaktadır

Oxygen Delivery During Cardiopulmonary Bypass and Acute Renal Failure After Coronary Operations

Marco Ranucci, MD, Federica Romitti, MD, Giuseppe Isgrò, MD, Mauro Cotza, CCP, Simonetta Brozzi, CCP, Alessandra Boncilli, CCP, and Antonio Ditta, CCP

Departments of Cardiothoracic Anesthesia and Intensive Care and Cardiovascular Perfusion, Policlinico San Donato, Milan, Italy

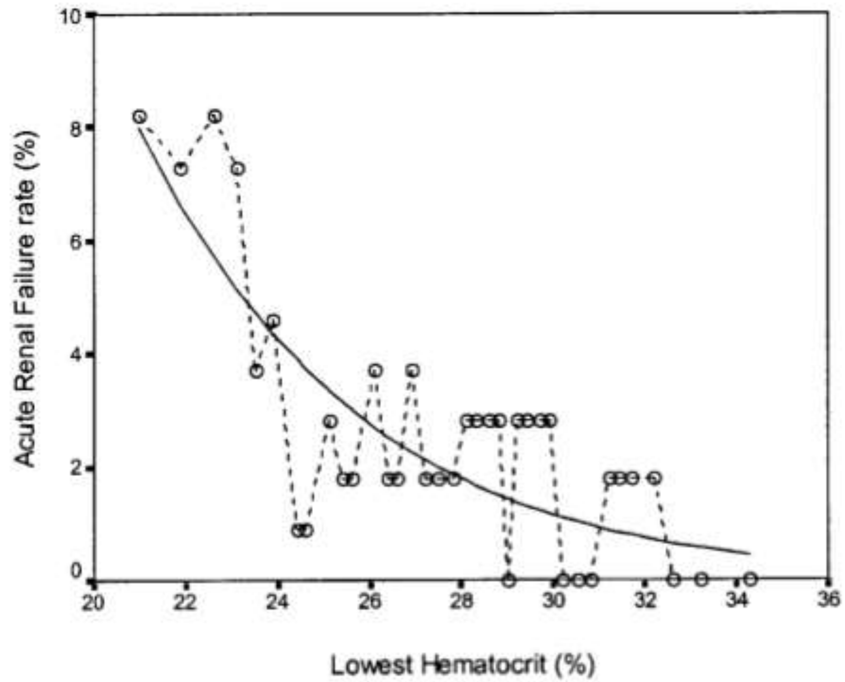
Background. The degree of hemodilution during cardiopulmonary bypass has recently been identified as an independent risk factor for acute renal failure after cardiac operations. In this prospective observational study we have investigated the role of the lowest oxygen delivery, lowest hematocrit, and pump flow during cardiopulmonary bypass as possible risk factors for acute renal failure and renal dysfunction.

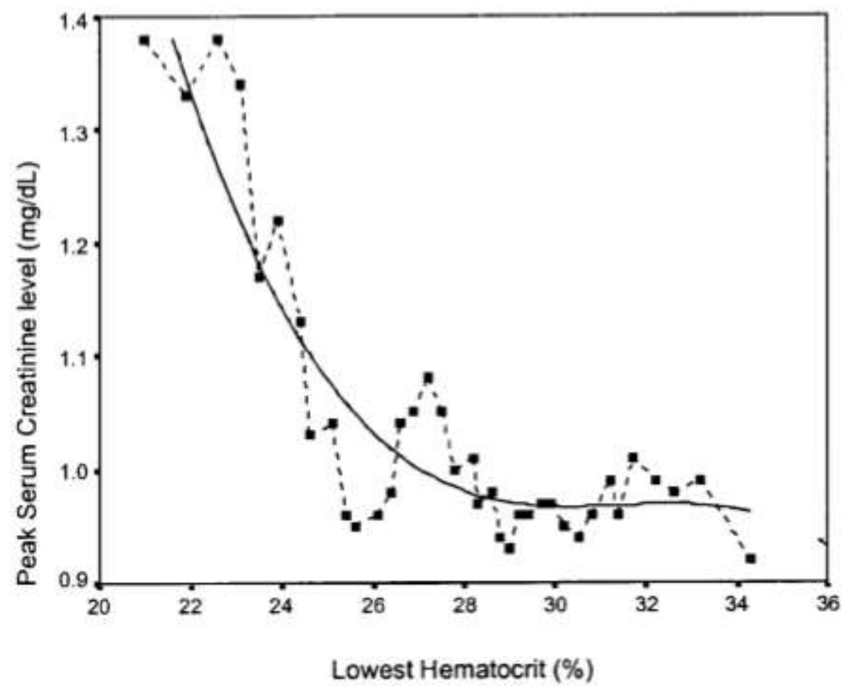
Methods. One thousand forty-eight consecutive patients undergoing coronary operations have been studied. For each patient we have recorded the lowest hematocrit on cardiopulmonary bypass, the correspondent lowest oxygen delivery, and the pump flow around the time of these determinations. The three variables have been explored in a multivariable model as possible risk factors for acute renal failure and postoperative serum creatinine levels increase. The role of transfusions in determining acute renal failure was subsequently included in the model.

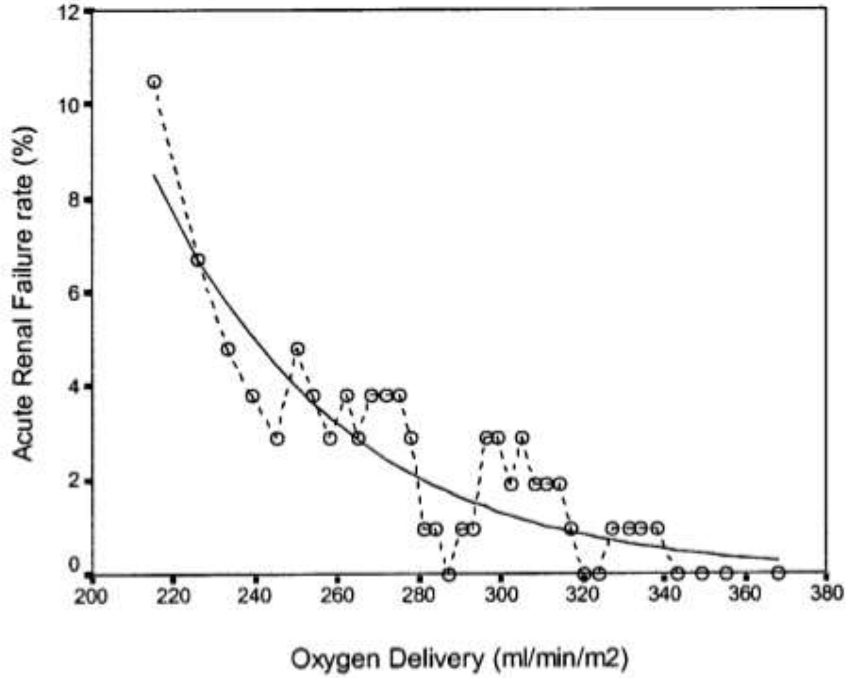
Results. The best predictor for acute renal failure and peak postoperative serum creatinine levels was the lowest oxygen delivery, with a critical value at 272 $mL \cdot min^{-1} \cdot m^{-2}$. The lowest hematocrit was an independent risk factor with a lowest predictive value at a cutoff of 26%. When corrected for the need for transfusions, only the lowest oxygen delivery remained an independent risk factor.

Conclusions. A high degree of hemodilution during cardiopulmonary bypass is a risk factor for postoperative renal dysfunction; however, its detrimental effects may be reduced by increasing the oxygen delivery with an adequately increased pump flow.

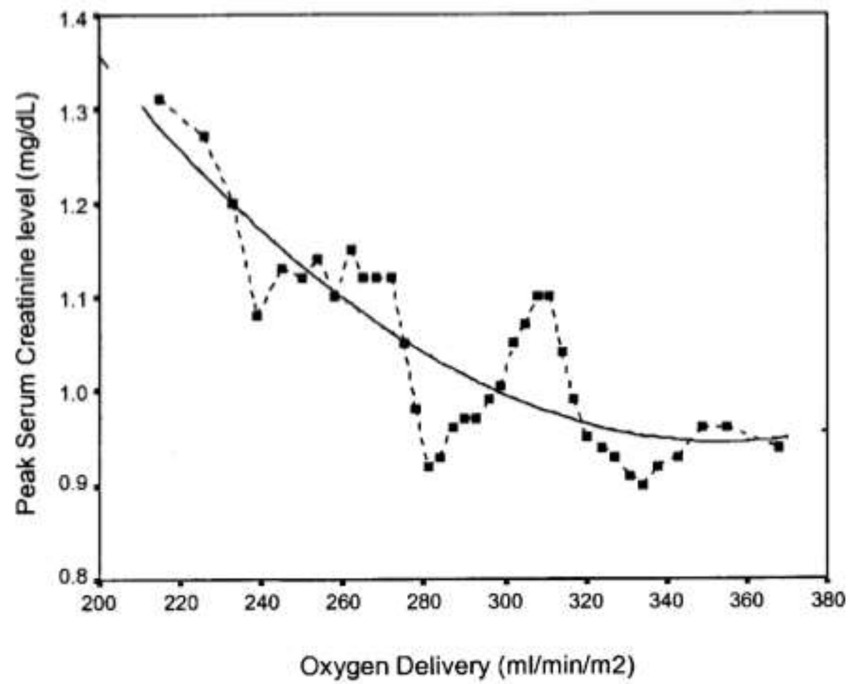
(Ann Thorac Surg 2005;80:2213–20)


Acute Renal Failure rate (%)
Lowest Hematocrit (%)


Peak Serum Creatinine level (mg/dL)
Lowest Hematocrit (%)



Acute Renal Failure rate (%)
0
2
4
6
8
10
12
200
220
240
260
280
300
320
340
360
380
Oxygen Delivery (ml/min/m2)



Peak Serum Creatinine level (mg/dL)
0.8
0.9
1.0
1.1
1.2
1.3
1.4
200
220
240
260
280
300
320
340
360
380
Oxygen Delivery (ml/min/m2)

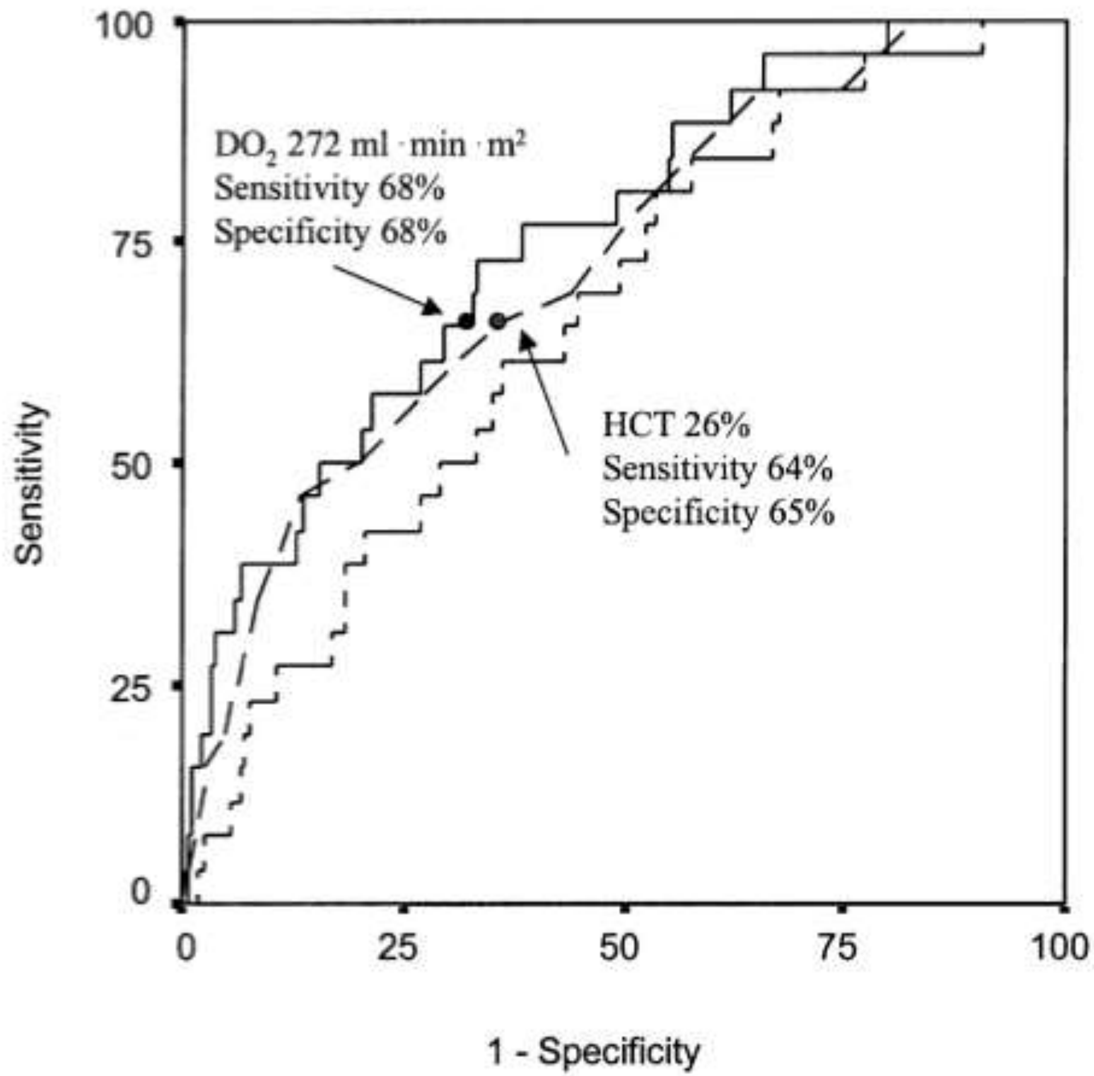
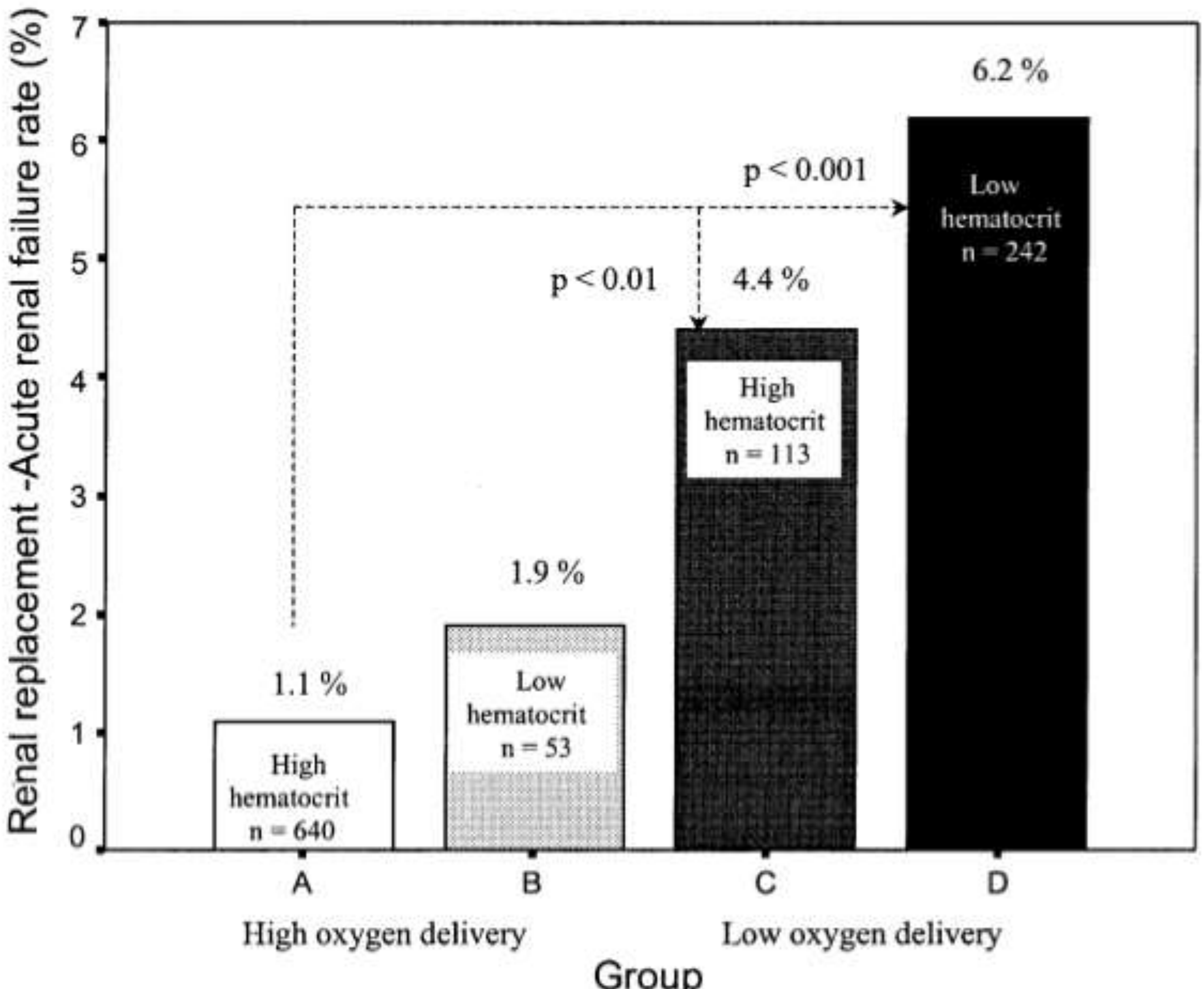


Fig 2. Receiver operating characteristic curve for the three variables being identified as independent risk factors for acute renal failure. — — = lowest hematocrit on CPB; - - - - = pump flow indexed; —— = oxygen delivery indexed. (CPB = cardiopulmonary bypass; DO_2 = *two determinants of oxygen delivery;* HCT = *hematocrit.)*


Renal replacement -Acute renal failure rate (%)
7
6
5
4
3
2
1
0
6.2 %
p < 0.001
Low hematocrit n = 242
p < 0.01
4.4 %
High hematocrit n = 113
1.9 %
1.1 %
Low hematocrit n = 53
High hematocrit n = 640
A
B
C
D
High oxygen delivery
Low oxygen delivery
Group

SONUÇ

- Bu konuda yapılmış önceki tüm çalışmalarda KPB sırasındaki düşük Hct ile postop renal disfonksiyon arasında ilişki bulunmuş olmasına rağmen,
  - Bu çalışmaların hiçbirinde pompa kan akımı dolayısıyla DO_2 göz önüne alınmadığından,
  - Hct'in direkt olarak suçlanmasının mümkün olamayacağını,
  - Aynı Hct değerlerinde pompa kan akım oranındaki farklılıkların %20-30 DO_2 oranını değiştirdiğini,
  - KPB sırasında asıl olan parametrenin DO_2 olduğunu ifade etmişlerdir.

Transfüzyon

- Transfüzyondan 1 saat sonra
- % 30 eritrosit hemoliz olmakta
- Serbest Hb açığa çıkmakta
- Makrofaj tarafından temizlenmeye çalışılmakta
- Serbet Hb den yavaş olarak Fe^{+++} salınmakta
- Transferin, serbest demiri bağlamaya çalışmakta
- Ancak, 2Ü RBC'den sonra serbest Fe konsantrasyonu 10 kat artmakta
- Bu nedenle dolaşımda serbest Hb ve Fe bulunmakta
- Bunlar ise;
  - NO azalmasına neden olarak ve
  - Kendilerinin prooksidan olmaları nedeni ile mikrosirkülasyonu bozmaktalar

Sonuç

1. Aneminin iyi olduğunu gösteren çalışma YOK
2. Özellikle Anemik Hastalarda Transfüzyonun Kötü Olduğunu Gösteren Çok Çalışma VAR
3. Kısa süreli anemi başarı ile idare edilebilir
   - KPB akımı artırılarak
   - Hipotermi sağlayarak
   - Anestezi derinliği artırılarak
4. Anemi tedavi edilebilir
5. Transfüzyon tedavi edilemez

- **Teşekkürler…**