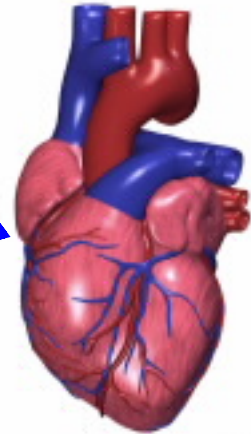
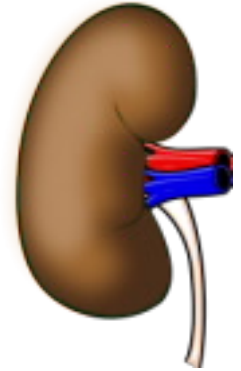
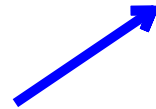
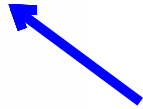
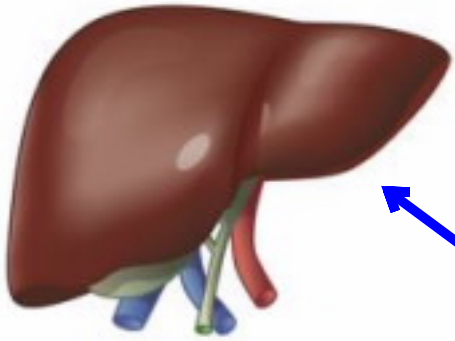


Relationship between Intraoperative Mean Arterial Pressure and Clinical Outcomes after Noncardiac Surgery

Toward an Empirical Definition of Hypotension



Liu Bing



15133 patients $\xrightarrow{\text{troponin}}$ 11.6%

1166 patients $\xrightarrow{\text{serum creatinine}}$ 7.5%

Ischemia–reperfusion injury due to **hypotension** may substantially contribute to postoperative AKI and myocardial injury

Hypotension ~~90/60~~mmHg

MAP



AKI
Myocardial injury



I WANT YOU

- ✓ **Non cardiac surgery**
- ✓ **Stayed at least one night in hospital**
- ✓ **Measured preoperative creatinine**
- ✓ **At least one postoperative creatinine**

Definition of AKI and myocardial injury

highest postoperative concentration(within 7 days after surgery)

preoperative concentration

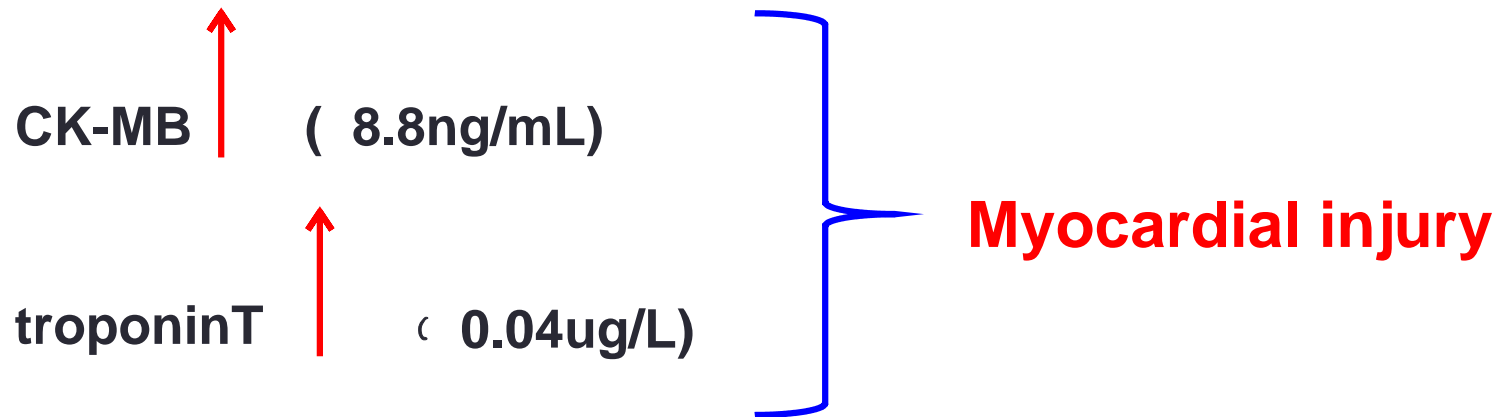


1.5-fold or more than 0.3 mg/dl greater



AKI

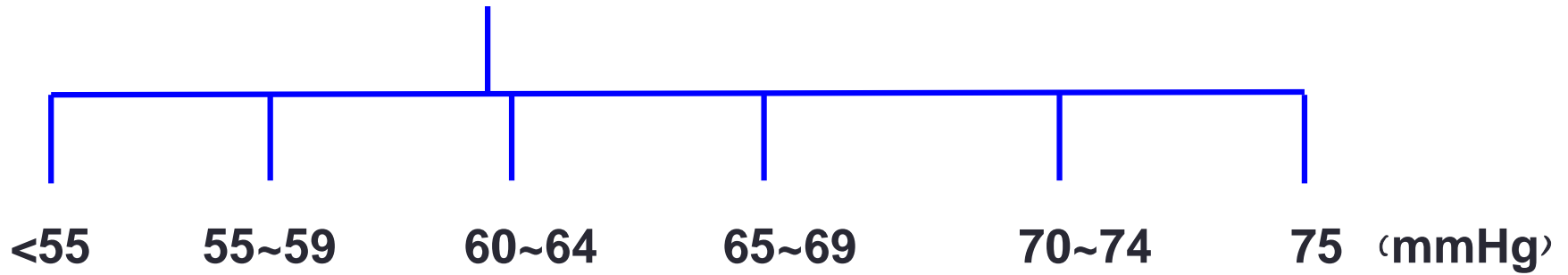
Definition of AKI and myocardial injury



MAP

IBP: 1-2min (44.5%)

NBP: 2-5min (55.5%)



Results

AKI occurred after 2,477 surgeries (7.4%) of which 2,043 (82.4%) occurred within 3 days of surgery. Myocardial injury was documented in 770 surgeries (2.3%), and 926 (2.8%) had a cardiac complication after surgery. Five hundred six patients (1.5%) died within 30 days of surgery.

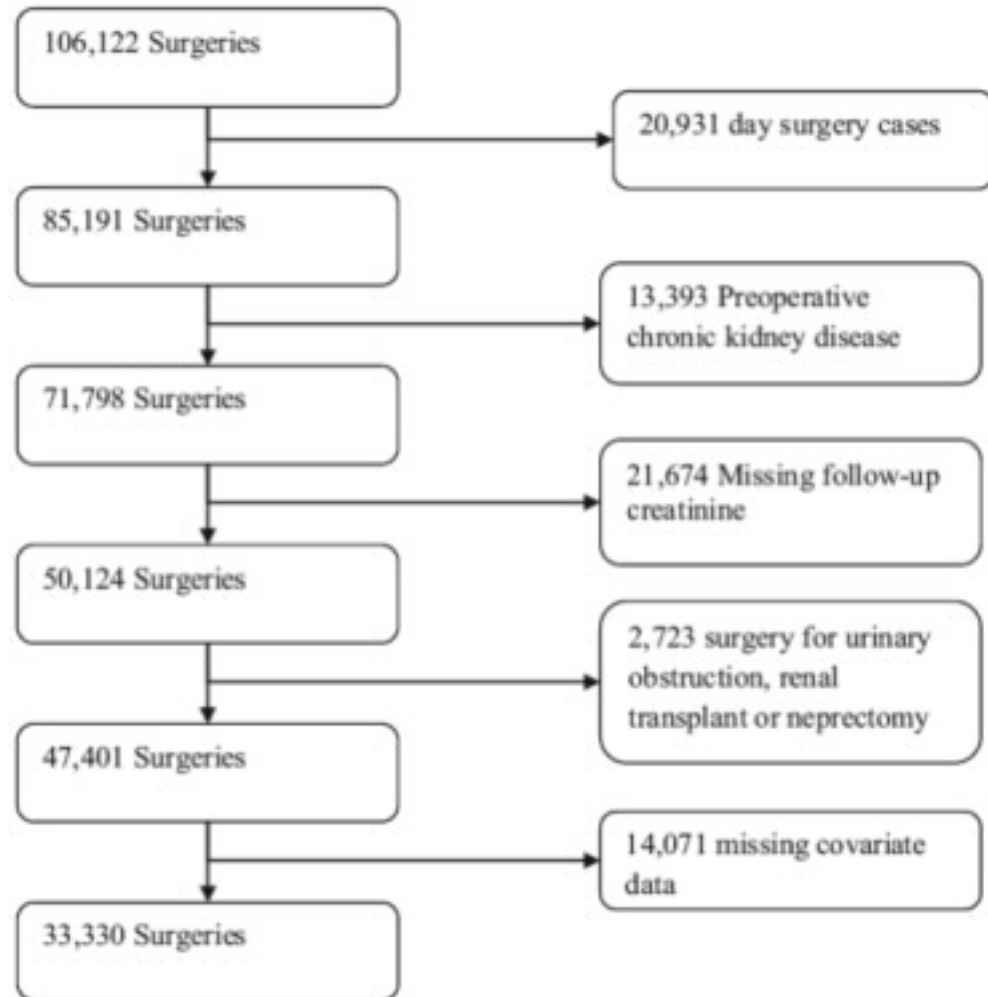


Fig. 1. Patient selection.

Results

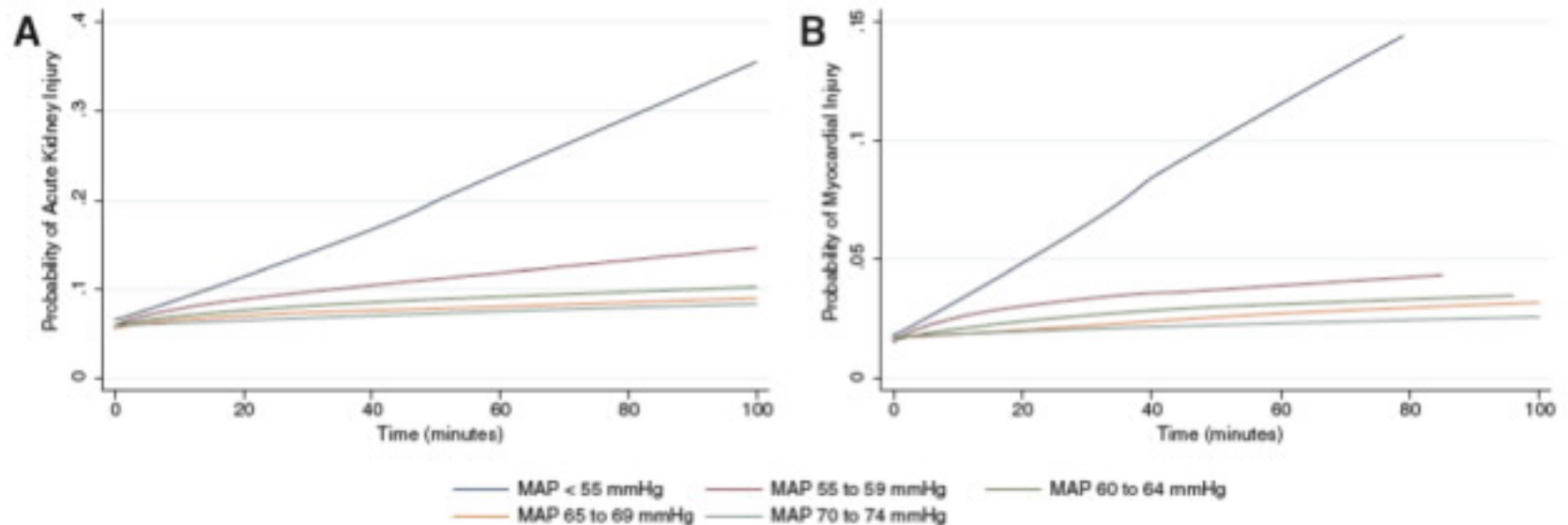


Fig. 2. Predicted risk of (A) acute kidney injury and (B) myocardial injury for each minute the mean arterial pressure (MAP) is <55 mmHg, between 55 and 59 mmHg, between 60 and 64 mmHg, between 65 and 69 mmHg, and between 70 and 74 mmHg during noncardiac surgery. The risk for time in each blood pressure strata is adjusted for time in all other blood pressure strata.

Results

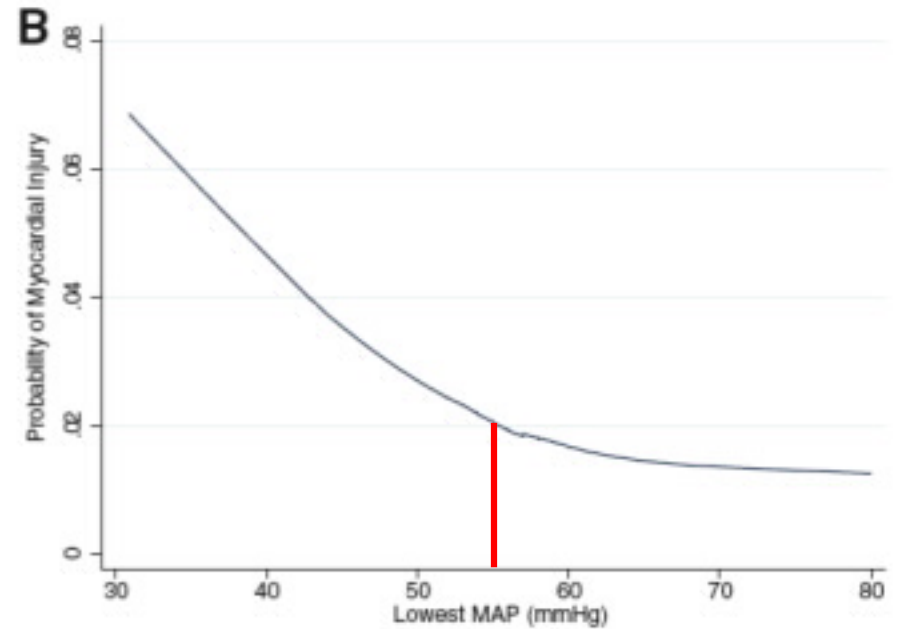
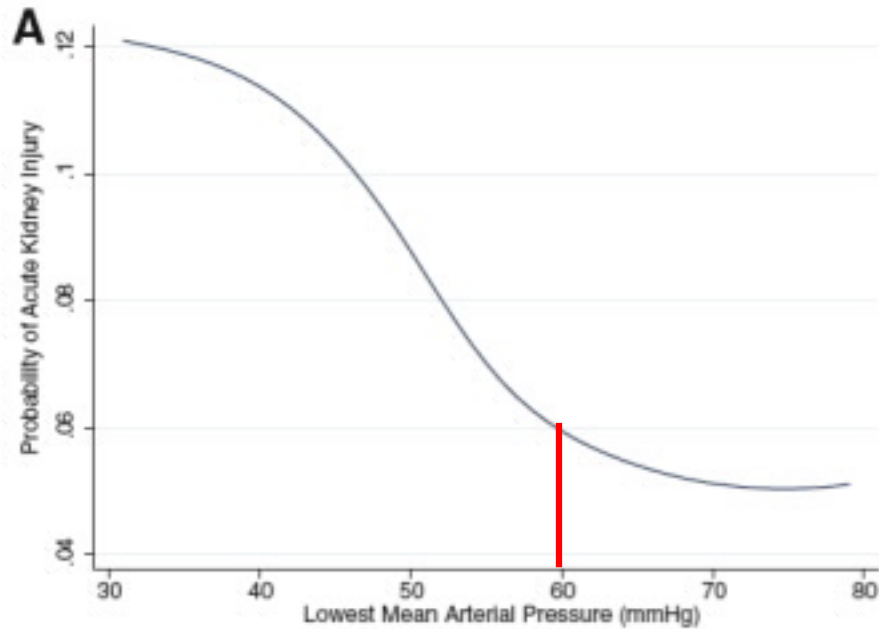


Fig. 3. Predicted probability of (A) acute kidney injury and (B) myocardial injury by lowest mean arterial pressure (MAP) experienced during surgery.

Results

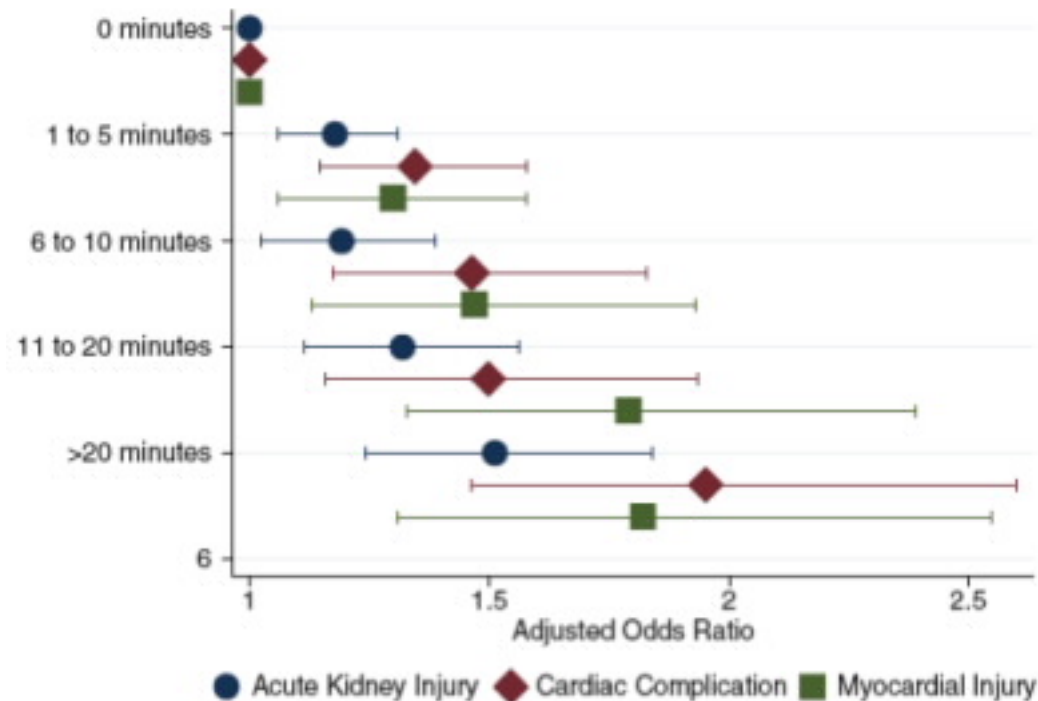


Fig. 4. Adjusted odds ratios for acute kidney injury, cardiac complications, and myocardial injury by time spent with a mean arterial pressure <55 mmHg.

Results

Table 1. Patient Characteristics by Operative Time Spent with a MAP <55 mmHg

	MAP <55 mmHg					P Value
	Never n = 18,989	1–5 min n = 8,266	6–10 min n = 2,856	11–20 min n = 1,987	>20 min n = 1,232	
Age, yr*	54.8 (15.3)	57.3 (15.5)	57.9 (15.6)	56.1 (16.6)	55.7 (16.7)	<0.001
Female, n (%)	9,519 (50.0)	4,102 (49.6)	1,516 (53.1)	1,064 (53.5)	635 (51.5)	<0.001
Emergency procedure, n (%)	1,063 (5.6)	579 (7.0)	193 (6.8)	188 (9.5)	144 (11.7)	<0.001
ASA score, n (%)						
I	418 (2.2)	121 (1.4)	42 (1.5)	26 (1.3)	16 (1.3)	<0.001
II	8,262 (43.6)	2,965 (35.9)	1,022 (35.8)	652 (32.8)	347 (28.2)	
III	9,120 (48.1)	4,387 (53.1)	1,521 (53.3)	1,087 (54.7)	654 (53.1)	
IV	1,143 (6.0)	767 (9.3)	264 (9.2)	218 (11.0)	211 (17.1)	
V	28 (0.1)	24 (0.3)	7 (0.2)	4 (0.2)	4 (0.3)	
Charlson Index†	0 (0 to 2)	1 (0 to 2)	1 (0 to 2)	1 (0 to 2)	1 (0 to 2)	<0.001
Diabetes mellitus, n (%)	2,424 (12.8)	1,056 (12.8)	384 (13.4)	246 (12.4)	156 (12.7)	0.71
Myocardial infarction, n (%)	699 (3.7)	387 (4.7)	143 (5.0)	88 (4.4)	43 (3.5)	<0.001
Congestive heart failure, n (%)	581 (3.1)	302 (3.7)	90 (3.2)	85 (4.3)	43 (3.5)	<0.001
Peripheral vascular disease, n (%)	576 (3.0)	474 (5.7)	150 (5.3)	97 (4.9)	57 (4.6)	<0.001
Stroke, n (%)	796 (4.2)	495 (6.0)	150 (5.2)	88 (4.4)	84 (6.8)	<0.001
Estimated GFR, ml·min ⁻¹ ·1.73m ⁻² *	92.3 (26.3)	91.7 (26.7)	93.2 (29.6)	94.9 (32.2)	96.6 (33.8)	<0.001
Hemoglobin, g/dl*	13.1 (2.0)	13.0 (2.0)	12.8 (2.1)	12.6 (2.1)	12.3 (2.1)	<0.001
Intraoperative erythrocyte transfusions, ml†	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 320)	0 (0 to 690)	<0.001
Estimated blood loss, ml†	200 (80 to 350)	250 (100 to 550)	250 (100 to 600)	300 (100 to 700)	400 (163 to 1,000)	<0.001

P values for continuous data computed by ANOVA. P values for frequency data computed by chi-square test.

* Mean (SD). † Median (first to third quarter).

ASA = American Society of Anesthesiologists; GFR = glomerular filtration rate; MAP = mean arterial pressure.

Results

Table 2. Adjusted Odds Ratios for Acute Kidney Injury, Myocardial Injury, and Cardiac Complications for Intraoperative Time Spent with a MAP <55 mmHg

Time MAP <55 mmHg (min)	Adjusted Odds Ratio (95% CI)			
	Acute Kidney Injury	Myocardial Injury	Cardiac Complication	30-day Mortality
0		Referent		
1–5	1.18 (1.06–1.31)	1.30 (1.06–1.58)	1.35 (1.15–1.58)	1.16 (0.91–1.46)
6–10	1.19 (1.03–1.39)	1.47 (1.13–1.93)	1.46 (1.17–1.83)	1.16 (0.84–1.60)
11–20	1.32 (1.11–1.56)	1.79 (1.33–2.39)	1.50 (1.16–1.94)	1.26 (0.89–1.80)
>20	1.51 (1.24–1.84)	1.82 (1.31–2.55)	1.95 (1.46–2.60)	1.79 (1.21–2.65)

Estimates adjusted for patient age, sex, Charlson comorbidity index, emergency procedure status, type of surgery, preoperative hemoglobin, decrement in hemoglobin concentration, estimated blood loss, and volume of erythrocyte transfusions.

MAP = mean arterial pressure.

Results

Table 3. Comparison of Results for Primary Analysis of Acute Kidney Injury Outcome Compared with Sensitivity Analyses

		Time Mean Arterial Pressure <55 mmHg (min)				
		0	1–5	6–10	11–20	>20
Primary	Referent	1.18 (1.06–1.31)	1.19 (1.03–1.39)	1.32 (1.11–1.56)	1.51 (1.24–1.84)	
AKI within 3 d	Referent	1.15 (1.02–1.29)	1.15 (1.00–1.35)	1.30 (1.09–1.56)	1.45 (1.17–1.80)	
Severe AKI	Referent	1.05 (0.77–1.50)	1.70 (1.16–2.63)	1.20 (0.70–2.11)	1.31 (0.72–2.37)	
Adjusted for RSI	Referent	1.12 (1.01–1.25)	1.13 (1.00–1.32)	1.23 (1.04–1.46)	1.36 (1.12–1.66)	
Adjusted for preoperative systolic blood pressure	Referent	1.19 (1.07–1.33)	1.17 (1.00–1.38)	1.30 (1.10–1.56)	1.55 (1.26–1.91)	
Adjusted for case duration	Referent	1.11 (1.00–1.24)	1.12 (0.97–1.30)	1.22 (1.03–1.45)	1.33 (1.09–1.62)	
Multiple imputation of missing covariates	Referent	1.24 (1.12–1.37)	1.25 (1.09–1.45)	1.38 (1.18–1.63)	1.58 (1.31–1.91)	
Most recent surgery only	Referent	1.10 (0.99–1.26)	1.07 (0.90–1.29)	1.36 (1.10–1.68)	1.33 (1.03–1.71)	

All models are adjusted for patient age, sex, preoperative hemoglobin, Charlson Comorbidity score (except RSI model), preoperative hemoglobin, estimated blood loss, transfusions, emergency surgery, and type of surgery.

AKI = acute kidney injury; RSI = risk stratification index.

Results

Table 4. Comparison of Results for Primary Analysis of Myocardial Injury Outcome Compared with Sensitivity Analyses

		Time Mean Arterial Pressure <55 mmHg (min)				
		0	1–5	6–10	11–20	>20
Primary	Referent	1.30 (1.06–1.58)	1.47 (1.13–1.93)	1.79 (1.34–2.39)	1.82 (1.31–2.55)	
Restricted to patients with troponin T measured (n = 4,533)	Referent	0.99 (0.80–1.20)	1.12 (0.84–1.50)	1.32 (1.00–1.79)	1.35 (0.99–1.90)	
Adjusted for RSI	Referent	1.21 (0.99–1.48)	1.35 (1.03–1.78)	1.60 (1.22–2.10)	1.67 (1.23–2.25)	
Adjusted for preoperative systolic blood pressure	Referent	1.15 (0.95–1.43)	1.26 (0.96–1.70)	1.54 (1.15–2.08)	1.56 (1.11–2.17)	
Adjusted for case duration	Referent	1.27 (1.05–1.53)	1.44 (1.12–1.86)	1.72 (1.30–2.26)	1.89 (1.39–2.58)	
Multiple imputation of missing covariates	Referent	1.31 (1.10–1.57)	1.48 (1.16–1.89)	1.85 (1.42–2.40)	2.03 (1.51–2.72)	
Most recent surgery only	Referent	1.21 (0.97–1.52)	1.05 (0.75–1.47)	1.51 (1.08–2.13)	1.58 (1.07–2.32)	

All models are adjusted for patient age, sex, preoperative hemoglobin, Charlson Comorbidity score (except RSI model), preoperative hemoglobin, estimated blood loss, transfusions, emergency surgery, and type of surgery.

RSI = risk stratification index.

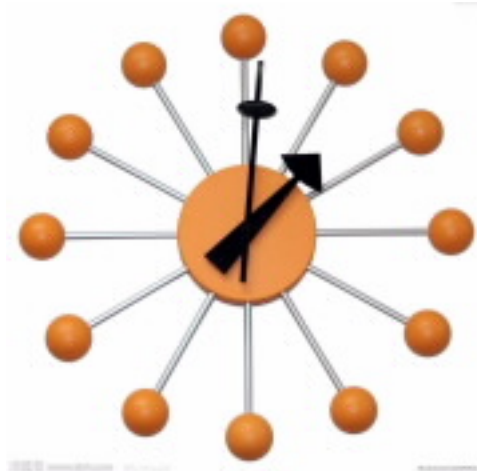
Conclusions

1

> 55 mmHg

2

×



Discussions

“hot topic”

electronically recorded blood pressures

large sample size provided sufficient statistical power

statistics

“clinical trial”