Managing Hyperkalemia and Hyperglycemia following a Large Dose of Buckberg Cardioplegia

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Patient Diagnosis

- 66 yo female with normal renal function, moderate AI, severe three vessel CAD
- History of smoking, emphysema, htn, hld, lung cancer, moderate carotid artery occlusive disease
- 51 Kg and 166 cm
- BSA 1.53m^2
- Presented with NSTEMI
- Severe occlusion of LAD, OM, and RCA
- IABP placed preoperatively
- Baseline normothermic ABG read pH 7.43, pCO2 38, PO2 88, HCT 32%, Na 137, Glucose 101, Calcium 1.21, Potassium 4.0
- 10.54 Liters Cardioplegia given (2.1 L crystalloid)
- Following morning her ABG normalized at K 4.8, calcium 1.16, glucose 113, chloride 106, sodium 144, and HCT 28%

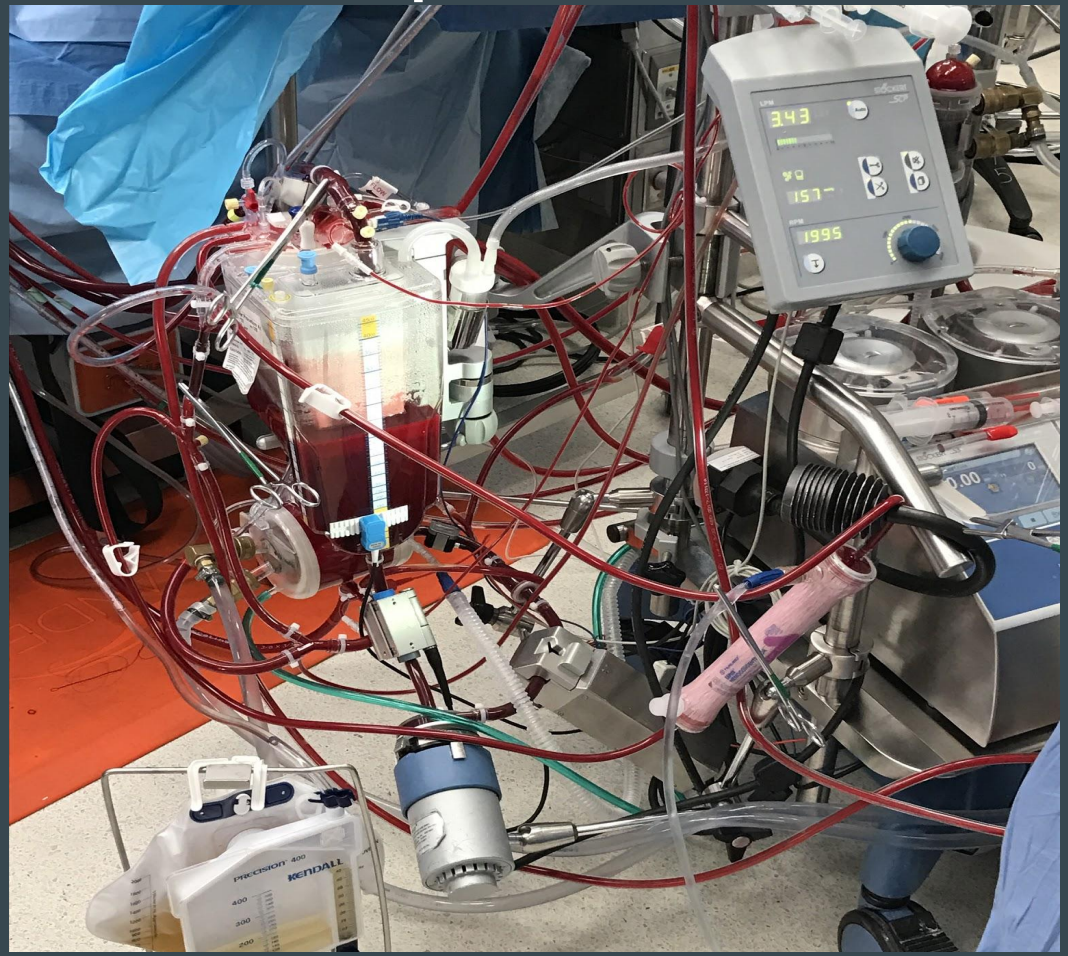
Case Report

- LIMA and 2 lengths of vein harvested
- Heparinized and cannulated on distal ascending aorta with 21 Fr. arterial cannula and a 28/36 Fr. venous in the right atrium and IVC (Edwards, Irvine, Ca.)
- Indirect retrograde catheter placed into coronary sinus and IABP turned off
- CPB initiated and the cross clamp placed followed by 354 mL of antegrade Buckberg cold blood cardioplegia (ABCBC)
- 1241 mL of retrograde Buckberg cold blood cardioplegia(RBCBC) and then 189 mL of ABCBC
- Patient cooled to 32 Centigrade venous temperature and converted to Bicaval cannulation with 24 Fr. right angle and 24 Fr. straight cannula (Edwards, Irvine, Ca.)

Case Report cont.

- Retrograde cannula was then placed directly into coronary sinus
- 1272 mL of RBCBC was then administered to arrest the heart and patient cooled to 28 degrees Centigrade
- Basket suction placed into PA
- Vein grafts to RCA, OM, and finally the LIMA to LAD was completed
- Retrograde was ran down each vein after each anastomosis totalling 6783 mL
- Next ABG read K 8.4, glucose 554, calcium .74, and HCT 20%
- 2 units of pRBCs were then administered and Z-Buf was initiated with a hemoconcentrator HC11 (Terumo, Tokyo, Japan) replacing plasma volume with .9% NS.

Hemoconcentrator Set Up



Case Report cont.

- Surgeon then excised aortic valve leaflets and a 19 mm St. Jude trifecta valve was sutured into place
- 1 more unit of pRBCs and 600 mL of cell saver RBCs
- ABG read K 7.7, HCT 27%, Calcium .65, and glucose 577
- Surgeon then closed aorta and completed his proximal anastomosis while perfusion and anesthesia team rewarmed the patient, continued to Z-BUF, and infused insulin
- After an hour of Z-BUF (4L), and insulin infusion, the ABG read K 4.8, glucose 410, HCT 28%

Case Report cont.

- Cross clamp removed after running a combined dose of 708 mL of antegrade and retrograde warm blood (hot shot) cardioplegia and 2711 mL of antegrade warm blood
- Patient's heart began beating following the surgeon's Kay annuloplasty stitch of the tricuspid valve
- 13.6 mEq of calcium chloride administered
- IABP turned back on at 1:2
- On bypass urine was 180 mL
- Bypass time of 154 minutes
- Total dose of 10.54 liters of cardioplegia given = 2.1 L crystalloid
- Following morning her ABG normalized at K 4.8, calcium 1.16, glucose 113, chloride 106, sodium 144, and HCT 28%
- Discharged 11 days later

Discussion

- Modified Buckberg Cardioplegia: Delivered in a 4 to 1 ratio of blood to crystalloid

	Induction (500mL)	Maintenance (1000 mL)	Reperfusate (500 mL)
MSA/MSG 0.92 Molar	0 mL	0 mL	62.5 mL
Tromethamine 0.3 Molar	60 mL	123 mL	56 mL
CP2D	30 mL	61 mL	113 mL
Dextrose 70%	28 mL	57 mL	26 mL
Sodium Chloride 4 mEq/mL	3.4 mL	6.8 mL	0 mL
Potassium Chloride 2 mEq/mL	18 mL	18 mL	7.5 mL

- 36 mEq of potassium administered for induction dose and after 2 units of pRBCs potassium rose to 7.5 and reached 8.4 at its highest level
- Adverse effects of hyperkalemia when weaning from CPB are well known including slowed myocardial contraction, cardiac arrhythmias, and even asystole (1)

Discussion

- Z-BUF began using .9%NS as replacement fluid along with addition of 250 mL of 8.4% sodium bicarbonate throughout case to balance acidity
- Total of 85 mEq of potassium were administered from crystalloid cardioplegia and about 5mEq/L of pRBCs totalling 90 mEq of potassium
- It has been shown that the high chloride content of NS can exacerbate hyperkalemia as a result of chloremic acidosis(3)
- SID of NS is zero thus administering large amounts can dilute normal plasma SID leading to acidosis and causing potassium to shift out of cells and into extracellular space (3)

Discussion

- Replacement Fluids

	Normal Plamsa	.9% Normal Saline	Modified Perfusate	PrismaSATE BK0/3.5
Potassium	3.5-5.0 mEq/L	0.0 mEq/L	0.0 mEq/L	0.0 mEq/L
Calcium	2.3-2.6 mEq/L	0.0 mEq/L	4.0 mEq/L	3.5 mEq/L
Magnesium	1.4-2.0 mEq/L	0.0 mEq/L	2 mEq/L	1.0 mEq/L
Sodium	140 mEq/L	154 mEq/L	134 mEq/L	140 mEq/L
Chloride	100-108 mE q/L	154 mEq/L	98 mEq/L	109.5 mEq/L
Bicarbonate	22-26 mEq/L	0 mEq/L	17 mEq/L (added)	32 mEq/L
Lactate	0.5-2.2 mEq/L	0.0 mEq/L	0.0 mEq/L	3.0 mEq/L
Dextrose	70-110 mOsm/L	0 mOsm/L	0 mOsm/L	0 mOsm/L
Osmolarity	280-296 mOsm/L	308 mOsm/L	252 mOsm/L	287 mOsm/L

- Calcium chloride and magnesium sulfate also administered as NS does not contain these electrolytes

Discussion

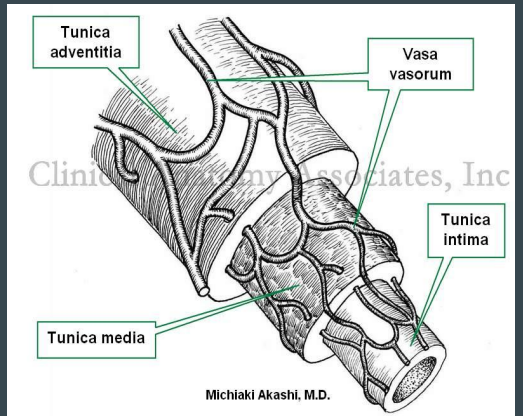
- High glucose levels during surgery have been found to be an independent predictor of mortality in patients with and without diabetes undergoing CABG surgery (4).
- During CPB, the rate of consumption of glucose as a fuel is decreased, along with a reduction in the glomerular filtration rate and an enhanced reabsorption of glucose by the kidneys (4).
- It has been shown that a post-operative serum glucose level greater than 250 mg/dL is associated with a 10 fold increase in complications following surgery (5).

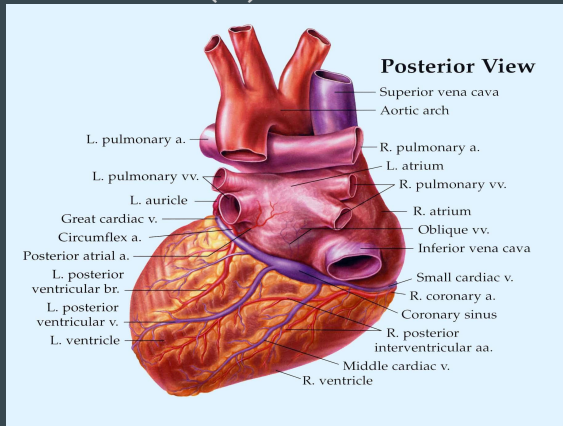
Discussion

- Due to the 10.54 liters of cardioplegia given (2.108 liters of crystalloid, 70% dextrose) and 3 units of pRBC's in CPD, the blood glucose level rose to 611 at its highest point.
- Insulin was continuously infused bringing glucose levels down by more than 200 mg/dL

Discussion

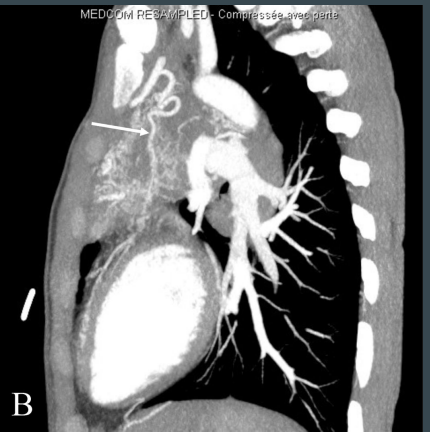
- An inability to completely arrest the heart can be seen in patients with three vessel coronary occlusion as there is enough collateral flow to the myocardium to wash out the cardioplegia and rewarm the heart (6)
- “Extracoronary collateral vessels can arise from internal mammary arteries, mediastinal, pericardial, and bronchial collateral channels that can enter the heart through pericardial reflections around the pulmonary and systemic veins as well as from the vasa vasorum along major vessels leading to the myocardium” (6)
- Rare and unpredictable



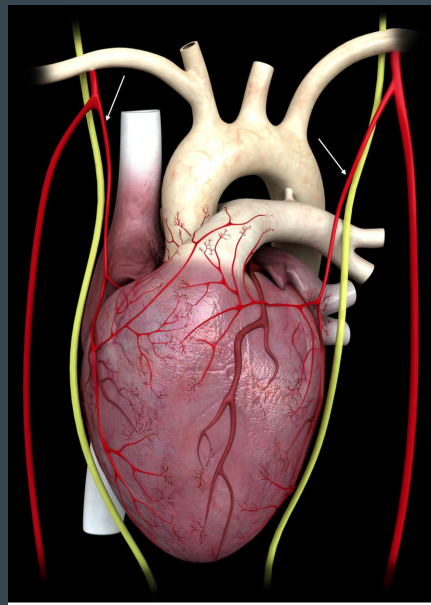


Discussion

- As much as 16 mL/ 100 gram myocardium/ minute collateral flow in dogs (9)
- 8mL/min of extracoronary collateral myocardial blood flow from systemic circulation found in human (8)
- As much as ⅕ of normal coronary artery flow can be from extracoronary flow (10)
- Collateral flow can be three times greater in three vessel coronary disease than valvular heart disease (9)
- Collateral flow can be reduced by reducing perfusion pressure
- Collateral flow increased with hemodilution



Angio CT Scan of IMA (10)



Pericardiophrenic artery (10)

Summary

- Case demonstrates successful approach at managing hyperkalemia and hyperglycemia during cardiac surgery
- Extracoronary collateral flow is rare and unpredictable and has serious effects on myocardial preservation
- Z-Buf, insulin infusion, and hemoconcentration are effective ways to lower potassium levels, lower glucose levels, and raise hematocrit respectively when large doses of cardioplegia are given

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