Cardiac Arrest: A Late Complication of Glucose-Insulin-Potassium (GIK) Therapy

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ABSTRACT

Rebound hyperkalaemia 4 hours after discontinuation of a glucose-insulin-potassium infusion inhibited an already compromised conduction system leading to ventricular standstill in a 41 year old man after re-do aortic valve surgery. Resuscitation was successful and allowed him to return from Australia to his home on Christmas Island.

Glucose-insulin-potassium (GIK) infusions to reduce myocardial hypo- / re-perfusion injury after myocardial infarction, during coronary artery surgery and cardiopulmonary bypass are becoming more popular. There may also be a role for GIK in the treatment of refractory dysrhythmias and for myocardial protection in the brain-dead patient. However, these infusions are not without hazard and this report of rebound hyperkalaemia and cardiac arrest is unlikely to remain isolated. (**Critical Care and Resuscitation 2001; 3: 101-104**)

Key words: Glucose-insulin-potassium, GIK, cardiac arrest, rebound hyperkalaemia, complications

The resurgence of glucose-insulin-potassium infusions in the 1990's has lead to an increase in their use in the setting of myocardial reperfusion. Fuelled by the positive results in the post-thrombolytic era, nothing but its lack of financial support or a series of adverse events can stop the use of this inexpensive mixture.

We report a near-fatal event after high dose GIK infusion in a 41 year old man after re-do aortic valve surgery.

CASE REPORT

A 41 year old Christmas Islander was admitted to hospital for replacement of his calcified aortic bioprosthesis. His medical history included juvenile rheumatic fever, aortic stenosis with left ventricular hypertrophy and heart failure treated by aortic valve replacement with a Hancock porcine prosthesis in 1985, when he was 25 years old.

On arrival at our institution, he was found to have clinical evidence of biventricular failure and signs of re-stenosis of his bioprosthetic aortic valve. The echocardiogram showed a dilated left ventricle with severe impairment of left ventricular function (EF 28%), a severely stenosed and calcified aortic valve with a peak gradient of 71mmHg and mean gradient of 48 mmHg. Coronary angiography revealed a 30% stenosis of the mid left anterior descending coronary artery. His preoperative plasma creatinine was 0.108 mmol/L.

His aortic valve was replaced with a 25 mm St Jude mechanical prosthesis at re-do thoracotomy, with relatively short cross-clamp (72 minutes) and bypass (136 minutes) times despite difficulties with adhesions and cannulation of the fragile and previously repaired aortic cannulation site. A mixture of glucose-insulin-potassium (glucose 27.5% 1.1 L, insulin 100 units, potassium chloride 80 mmol) was commenced and infused at 100 mL/hr both intra- and post-operatively to enhance left ventricular function.

On arrival in the intensive care unit, he was receiving noradrenaline at 10 μg/min, adrenaline at 6 μg/min, DOO pacing for 2 hr at 100 beats per min via epicardial wires, and an IABP at 1:1 with full augmentation. On the morning after surgery, his haemodynamic status had improved to the point where he could tolerate a reduction in IABP support and reduced vasopressor requirements. Sedation was discon-tinued and the IABP was removed at 12 40 hr. The plasma potassium at 11 00 hr was 4.45 mmol/L and the glucose-insulin-

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potassium infusion was weaned, then discontinued at 14 00 hr. He was extubated at 15 40 hr. His arterial pH was 7.30.

At 19 00 hr his pulse changed from sinus tachycardia of 100 beats per min to ventricular standstill, followed by hypotension and unconsciousness. He was rapidly paced via the epicardial wires, given a brief period of increased inotropic and vasoconstrictor support without external chest compression, and within an hour he was in sinus rhythm with a blood pressure restored to his pre-arrest values. The glucose-insulin-potassium infusion was recommenced at half the previous rate (i.e. 50 mL/hr) and supplementary insulin and dextrose (10 units of actrapid and 50 mL of 50% dextrose) were given when the plasma potassium was reported to be 6.8 mmol/L (figure1).

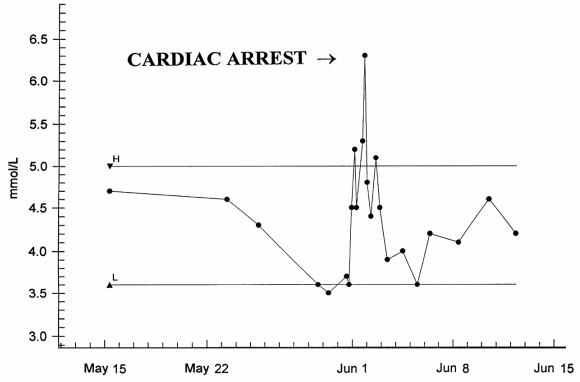
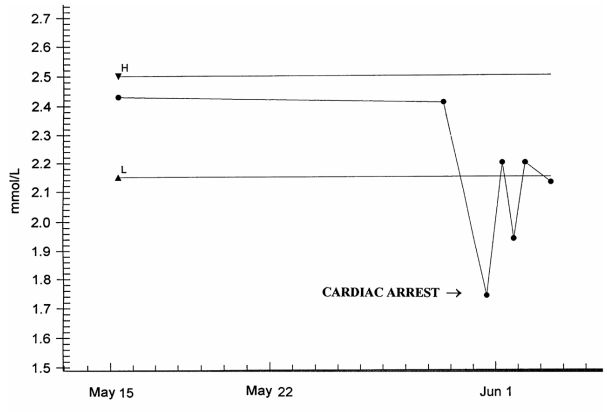


Figure 1. Plasma potassium levels preoperatively, intraoperatively (May 31) and one day later (June 1) when the cardiac arrest occurred.

Calcium salt supplementation (10 mL 10% calcium gluconate) was given slowly intravenously when his ionised calcium was found to be low (figure 2). The plasma magnesium levels are shown in figure 3.



igure 2. Plasma calcium levels preoperatively, intraoperatively and one day later (June 1) when the cardiac arrest occurred.

He was discharged to the cardiothoracic ward the following day, a permanent pacemaker was inserted on the tenth post-operative day following a further episode of ventricular standstill. He left hospital in good health on the 15th postoperative day.

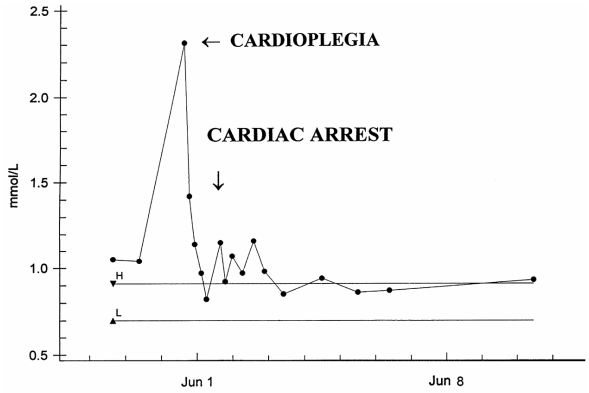


Figure 3. Plasma magnesium levels preoperatively, intraoperatively (during cardioplegia) and one day later (June 1) when the cardiac arrest occurred.

DISCUSSION

Sodi-Pallares *et al*, first suggested electrocardiographic benefits of GIK in myocardial infarction.[1] The repletion of myocardial glycogen content, as a less oxygen-dependent energy source in the setting of ischaemia, had been considered one of the main mechanisms of myocardial protection.[2] However, while myocardial glycogen content did rise remarkably quickly with GIK administration,[3] other mechanisms have been implicated.[4] Nevertheless, the mechanism of myocardial protection shifted to the diminution of circulating free fatty acids (an energy source now implicated in the oxygen free radical mediated effects of membrane damage),[5,6] arrhythmias and decreased cardiac function from reperfusion injury.

Experimental models of myocardial reperfusion injury preceded the first positive clinical results associated with GIK in the pre-thrombolytic era. However, treatment of myocardial infarction with thrombolysis shifted the therapeutic emphasis, and the interest in GIK therapy wained until prospective randomised controlled trials demonstrated dramatic efficacy with GIK therapy in the early treatment of myocardial infarction,[7] in addition to thrombolytic therapy[8,9]

Less clear is the role of GIK in patients with poor cardiac function and electrical conduction defects before, and after, cardiopulmonary bypass. Numerous small studies show an increase (not necessarily an improvement) in cardiac output in patients given variable doses and durations of GIK solutions before,

during and after coronary artery bypass surgery[2,10,11] and with mitral valve replacement.[3] Other end-points have been less startling. Studies in humans aiming to show myocardial protection by a reduction in enzyme rise (CK-MB) have been variably positive,[12] or inconclusive.[13] Benefits have also included a reduction in incidence of supraventricular dysrhythmias, less weight gain, earlier extubation and shorter intensive care unit and hospital stays, and less vasopressor requirement.[14,15]

"High dose" GIK, as used in our patient to improve myocardial performance, has been re-discovered in the treatment of myocardial infarction[8,9] and more controversially in myocardial protection and improved performance in coronary artery bypass surgery.[16] Its safety profile for myocardial infarction and its ease of use with minimal biochemical disturbance in the physiologically deranged setting of cardiopulmonary bypass, has led to its general acceptance, particularly as significant biochemical disturbances or side-effects have not been reported. Other proposed uses include management of refractory ventricular dysrhythmias,[17] and myocardial support for the brain-dead donor.[18]

At our hospital, we use a hybrid recipe of GIK for 12 hr in our post-CABG patients, which to date has caused few biochemical disturbances.[15] Transient hyperglycaemia intra-operatively (as occurred acutely in our patient, figure 4), may occur early during the period of hypothermia and has led to the supplementary use of an insulin infusion to more tightly control blood sugar levels.

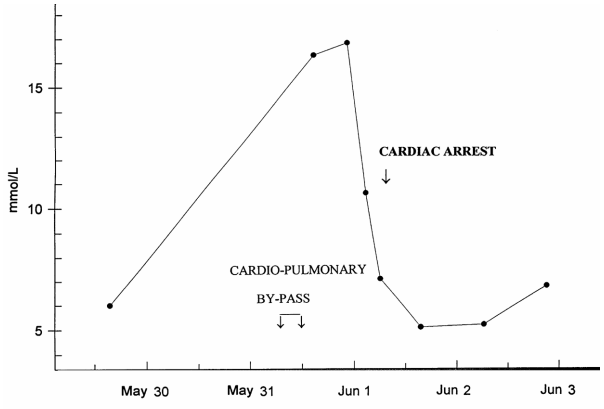


Figure 4. Plasma glucose levels preoperatively, intraoperatively and one day later (June 1) when the cardiac arrest occurred.

Potassium levels have always remained within the normal range although there has been a tendency to relative hypokalaemia during the infusion, followed by relative hyperkalaemia some hours following its cessation. This rebound hyperkalaemia may suggest a replenishment of potassium stores and artificial "loading" of cells, with a subsequent shift back to the extracellular space at completion of the insulin infusion. There is transient hypophosphataemia during the infusion (figure 5), which may also persist in the post-infusion phase and may contribute to poor myocardial contractility unless replaced.

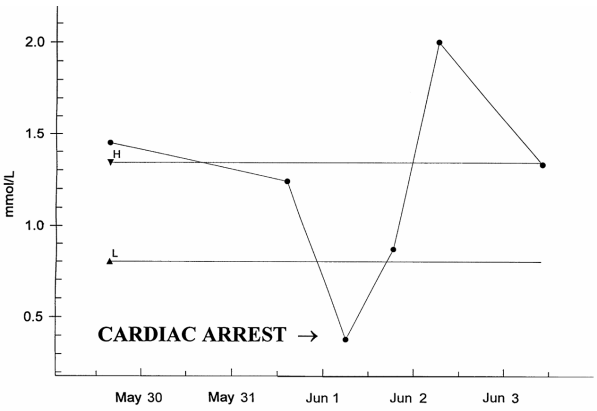


Figure 5. Plasma phosphate levels preoperatively, intraoperatively and one day later (June 1) when the cardiac arrest occurred.

This case report of ventricular standstill in a 41 year old patient after aortic valvular surgery, who was found to have an abrupt substantial rise in plasma potassium level at the completion of a prolonged (24 hr) high dose GIK infusion, is the first reported case of cardiac arrest partly attributable to this increasingly popular therapy.

The cause of this patient's cardiac arrest might have been apparent earlier or even avoided with more frequent checking of the plasma potassium level in the "post-GIK" phase, a time when most clinicians would assume that the biochemical disturbance of the infusion is well past.

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