Journal of Critical Care 29 (2014) 997–1000

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

Goal-directed therapy after cardiac surgery and the incidence of acute kidney injury

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ARTICLE INFO

Keywords:
Goal-directed therapy
Cardiac surgery
Acute kidney injury

ABSTRACT

Objective: The purpose of this study was to assess the effect of goal-directed therapy (GDT), after cardiac surgery, on the incidence of acute kidney injury (AKI).
Design: This is a prospective observational study designed to achieve and maintain maximum stroke volume for 8 hours, in patients after cardiac surgery.
Setting: This is a single-center study in a 15-bedded cardiothoracic intensive care unit (ICU).
Participants: Participants are patients after coronary artery bypass grafting and/or aortic valve surgery.
Interventions: Patients in the GDT group received cardiac output monitoring and fluid challenges targeting an increase in stroke volume by at least 10%. Stroke volume maximization was maintained for a period of 8 hours from admission to the ICU. All other aspects of care were dictated by the clinical team. Patients in the standard therapy (ST) group had intravenous fluids in accordance with the routine practice of the unit. Patients were divided into the GDT and ST group dependant on availability of cardiac output monitors and allocation of nursing staff with training in GDT. Patients' data were collected prospectively in both groups.
Measurements and main results: One hundred twenty-three patients received GDT compared with 141 patients in the ST group. Both groups received similar volumes of fluid (GDT, 2905 [1367] mL vs 2704 [1393] mL; $P = .09$). Incidence of AKI was reduced in the GDT group (n = 8 [6.5%] vs n = 28 [19.9%]; $P = .002$). The median duration of hospital stay was 6 (4) days in the GDT group vs 7 (8) days in the ST, $P = .004$.
Conclusion: Postoperative GDT in patients after cardiac surgery was associated with reduction in the incidence of AKI and a reduction in ICU and hospital duration of stay.

1. Introduction

There are more than 31 000 cardiac surgical procedures performed annually in the United Kingdom [1]. Up to 24% of patients, after cardiac surgery, develop acute kidney injury (AKI) with a subsequent 7-fold increase in mortality [2,3]. The mortality rate can be as high as 80% when renal replacement therapy (RRT) is required [4,5]. Many therapeutic strategies targeting AKI have been studied in the cardiac surgical population. Some of these include diuretics, dopamine, fenoldopam, calcium channel antagonists, atrial natriuretic peptide, N-acetylcysteine, and mannitol. No positive outcome was reported with any of these agents, while some showed deleterious effects on hemodynamics, renal function, and coagulation [6,7].

In the noncardiac surgical population, there are many observational studies that demonstrated an association between reduced cardiac index in the perioperative period and poor postoperative outcome [8–10]. Interventional studies where cardiac output and oxygen delivery were measured and artificially manipulated to achieve predefined hemodynamic goals showed a reduction in morbidity and, in some patient groups, improved survival [11–14]. Further work using minimally invasive cardiac output monitoring to achieve maximum stroke volume (SV_{max}) with intravenous fluid therapy resulted in a significant reduction in the rate of complications and duration of hospital stay [15–21]. The beneficial effect is likely to be attributed to the prevention of tissue hypoxia [22,23]. There are currently limited data in relation to the role of GDT in cardiac surgery specifically in relation to AKI, but it is thought that maintaining renal perfusion in the postoperative period may have a beneficial impact. Studies in this group of patients are hindered by the differing hemodynamic goals targeted and the heterogeneity in assessing postoperative outcome. However, 2 recent meta-analyses showed a beneficial impact of GDT on postcardiac surgery complications [24,25].

A GDT protocol (Fig. 1.) was recently introduced in a 15-bed cardiac intensive care unit (ICU) with the therapeutic target of SV maximization for the first 8 postoperative hours. The aim of this

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http://dx.doi.org/10.1016/j.jcrc.2014.06.011
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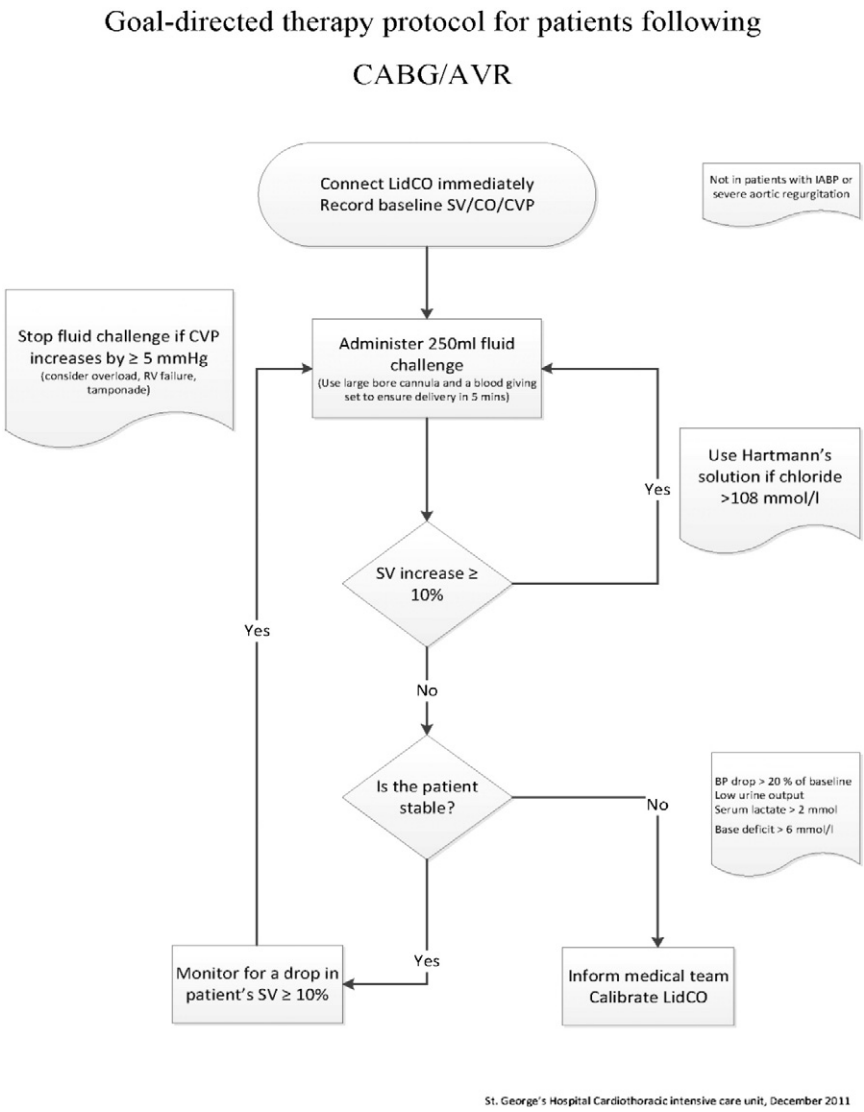

Fig. 1. Algorithm for SV maximization.

clinical evaluation is to assess the safety of this regimen in patients after cardiac surgery and its impact on renal dysfunction.

2. Materials and methods

This was a prospective, single-center, observational study of GDT, in patients after cardiac surgery and the effect on renal dysfunction. The GDT protocol was based on SV maximization implemented by the intensive care nursing team (Fig. 1). This work was part of a clinical evaluation of GDT in the cardiac surgery setting with the aim to improve fluid administration on the ICU. Therefore, formal ethical approval and informed consent were not required in accordance with the UK National Health Service research authority [26].

Data collection was performed prospectively between December 2011 and August 2012. The primary outcome measure was AKI as defined by the AKI Network based on changes in serum creatinine concentrations [27] Urine output was not used to identify AKI in this study to exclude the effect of diuretic administration [28]. The serum creatinine measured on the third postoperative day, compared with the most recent preoperative measurement, was used to identify AKI to minimize the dilutional effects in relation to cardiopulmonary bypass [29]. Secondary outcome measures were total fluids administered in the first 8 postoperative hours, commencement of RRT, duration of ICU stay, readmission rate to ICU, and duration of hospital stay.

There were patients who did not receive GDT either because of the lack of nurses trained to deliver this therapy or the unavailability of cardiac output monitors. Those patients established the "standard therapy" (ST) group for the purpose of this data analysis.

2.1. Participants

Adult patients undergoing on- and off-pump coronary artery bypass grafts (CABGs), aortic valve replacement (AVR), or combined CABG and AVR admitted to the ICU after surgery were included. These patients were selected due to the lower risk of right ventricular dysfunction.

2.2. Protocol

The GDT protocol is based on achieving and maintaining SV_{max} in the first 8 hours after admission to the ICU. The patients were connected to a continuous arterial pressure-derived cardiac output monitor (LiDCOplus; LiDCO Group plc, London, United Kingdom) and a fluid challenge of 250 mL administered within 30 minutes of arrival