

# Goal-directed Perioperative Fluid Management

## Why, When, and How?

PRINCIPLES of perioperative fluid management have received increased interest in recent years within type and amount of crystalloid and colloid, the concept of individualized goal-directed cardiovascular optimization (GDT), and finally assessed on a procedure-specific basis. In this issue, Kimberger *et al.*,<sup>1</sup> investigated the underlying tissue mechanisms during GDT management with crystalloids or colloids for abdominal surgery with a colonic anastomosis. This elegant experimental study in pigs included detailed techniques of postsurgical assessments of conventional cardiovascular variables (blood pressure, heart rate, urinary output) and microcirculatory blood flow and tissue oxygen tension in healthy and perianastomotic colonic tissue. Three types of fluid management were instituted at the end of surgery: restricted Ringer lactate (RL) *versus* GDT RL or GDT colloid to achieve a mixed venous oxygen saturation (SvO<sub>2</sub>) greater than 60%. The results show no significant differences between the groups in conventional cardiovascular functional parameters or urinary output, but an increased oxygen tension in healthy colonic tissue compared with RL and a further increase with GDT colloid compared with GDT RL. Of special interest, oxygen tension in perianastomotic tissue increased to 245% with GDT colloid *versus* 147% in the GDT RL group *versus* 116% in the restricted RL group. Furthermore, microcirculatory flow was higher with GDT colloid. Interestingly, anastomotic tissue edema was not different between groups.

The study by Kimberger *et al.*<sup>1</sup> may add important new knowledge to the understanding of the apparent beneficial effects of GDT in surgical patients, where the 11 randomized clinical studies have mostly shown outcome benefits within postoperative nausea and vomiting, ileus, morbidity, and hospital stay.<sup>2-5</sup> Until now, however, only limited pathophysiological data are available to explain this benefit. Thus, Mythen and Webb showed GDT to improve morbidity and hospital stay after cardiac surgery related to the demonstrated increased gut mucosal perfusion (gastric intramucosal pH),<sup>6</sup> but this could not be confirmed by a less well-designed study in abdominal surgery.<sup>4</sup> In the colorectal surgery study by

Noblett *et al.*,<sup>7</sup> the reduced morbidity and hospital stay by GDT was associated with a reduced interleukin-6 response. These findings together suggest that GDT may attenuate stress-induced organ dysfunctions and thereby have a pivotal role on outcome, including anastomotic complications. The recent studies on perioperative changes of the vascular barrier suggest that the endothelial glycocalyx plays a key role,<sup>8,9</sup> which needs to be studied within the context of GDT and use of colloid.

In the discussion of GDT, it is essential that the present *individualized* GDT approach includes optimization of flow-related parameters, such as cardiac stroke volume, within the limit of the individual patient's cardiac capacity.<sup>2,3,10,11</sup> The concept is therefore different from the original Shoemaker concept for optimization, which used predetermined supraphysiologic values of cardiac index and Do<sub>2</sub> as therapeutic goals.<sup>12</sup> Interestingly, the study by Kimberger *et al.*<sup>1</sup> also used fixed goals for GDT optimization (SvO<sub>2</sub> > 60%) and not the individualized approach.

Most of the 11 clinical GDT outcome studies are positive<sup>2-5</sup> and may have widespread implications for clinical practice; therefore, there is an urgent need to evaluate the pathophysiological mechanisms, such as done by Kimberger *et al.*<sup>1</sup> and others.<sup>6,7</sup> In addition, *when* to institute GDT needs to be clarified. The studies predominantly perform GDT in the intraoperative period, and there have been only 2 studies within the very early postoperative period<sup>13,14</sup> and no studies in the later postoperative period, where major fluid shifts and requirements may occur. Interestingly, the GDT optimization by Kimberger *et al.* was done postabdominal closure.<sup>1</sup> However, the studies<sup>2-5</sup> provide little or no detailed data of GDT in relation to type of anesthesia, including epidural anesthesia and its well-known effects on cardiovascular function; therefore, the practicing anesthesiologist is left with several unanswered questions for the interpretation of the GDT approach during the entire anesthetic-surgical period. In this context, precision of GDT requires averaging of stroke volume over at least 10 heartbeats when using the esophageal Doppler technology.<sup>15</sup> Also, it has been suggested that the timing of GDT may be important because the total perioperative administration of crystalloid and colloid was not different between the GDT and control groups, despite major differences in outcome in favor of GDT.<sup>7</sup> These results again call for confirmative studies, as well as pathophysiological explanations. Colloids for GDT have been used in the clinical studies<sup>2-5</sup> and are supported by the study by Kimberger *et al.*<sup>1</sup> as well as by a previous study<sup>16</sup> demonstrating that GDT-administered crystalloid

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is less beneficial or not beneficial. These findings may be explained by the more prolonged intravascular volume expansion and improved tissue oxygenation by colloids compared to crystalloids,<sup>17,18</sup> and beneficial pharmacological effects of hetastarch preparations on the endothelium have been suggested.<sup>19,20</sup>

Despite the apparent improvements in postoperative outcome by the GDT concept,<sup>2-5</sup> all studies have problems with insufficient design regarding well-defined principles of perioperative care, discharge criteria, and information about reasons for postoperative hospitalization. Recent developments in perioperative care based on the concept of fast-track surgery,<sup>21</sup> *i.e.*, a multimodal approach by combination of single-modality, evidence-based care principles have shown major benefits with enhanced recovery, decreased need for hospitalization, and medical morbidity.<sup>21</sup> The outcome benefits of the fast-track methodology are extensive and most often superior to what has been observed in the GDT studies.<sup>2-5</sup> Therefore, future studies are urgently needed where GDT is combined with the fast-track methodology<sup>21</sup> to obtain the maximum benefits of the GDT approach on a procedure-specific basis.<sup>22</sup>

Finally, if we are going to recommend more widespread use of GDT, the choice of monitoring system to guide fluid administration must be addressed. The previous use of the pulmonary artery catheter<sup>12</sup> may not be useful in the routine perioperative setting. Most clinical GDT outcome studies have used the esophageal Doppler system for stroke volume optimization,<sup>2,3</sup> which therefore presently may be considered a feasible choice until other more simple techniques have been documented to achieve similar outcome results. In this context, only limited data exist to compare other more practical flow-related modalities such as near infrared spectroscopy,  $SvO_2$  and model flow determined stroke volume with esophageal Doppler-based optimization.<sup>23</sup> Kimberger *et al.*<sup>1</sup> used  $SvO_2$  to guide fluid therapy, which may not respond as markedly as stroke volume during GDT optimization.<sup>23</sup> Interestingly,  $SvO_2$  optimization to a predetermined value of at least 70% has been associated with improved outcome in early treatment of sepsis,<sup>24</sup> but it has not been documented in elective surgical settings. Other modalities such as pulse contour analyses (PiCCO, LiDCO) have acceptable precision<sup>25,26</sup> and provide pulse pressure, systolic, and stroke volume variation, which may be reliable markers of fluid responsiveness during mechanical ventilation.<sup>27</sup> However, application of these parameters in the perioperative setting only comes from two outcome studies,<sup>4,5</sup> only one of which was positive.<sup>5</sup> To summarize, further development and assessment of monitoring systems for perioperative GDT is required with a focus on precision, feasibility, invasiveness, requirement of skill, and expertise and application for the entire perioperative period.<sup>2</sup>

In conclusion, the concept of individualized GDT in surgical patients seems to be an important component for optimization of perioperative fluid management and outcome in high-risk surgical patients.<sup>2,3,11</sup> However, GDT must be integrated with existing knowledge on the role of total amount of fluid,<sup>9,10,22</sup> the fast-track methodology,<sup>21,22</sup> and then in a procedure-specific approach because different procedures have different fluid pathophysiology. The time is now for clinical studies to define components of GDT practice, including algorithms, monitoring systems, and guidelines for the entire perioperative period.<sup>2</sup>

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