Editorial

# Has goal directed fluid therapy and glycocalyx a role in enhanced recovery after anesthesia?

Fluid management during surgery has been described as liberal or standard, restricted or zero balance, and or goal-directed fluid therapy (GDFT). The standard fluid calculation follows the 4-2-1 rule plus calculating the deficit of fasting and insensitive losses including compensatory intravascular volume expansion plus evaporation losses (10 mL/kg/h), plus the total blood loss. Restrictive fluid therapy includes replacement of the loss only but fluid overload recognized as postoperative weight gain should be avoided.[1] Several investigators have measured insensible perspiration (evaporation from the skin and airways). They found insensible perspiration to be approximately 0.3 mL/kg/h.[2] Another investigator documented the same result for patients during abdominal surgery, with 0.2 mL/kg/h water loss from respiration. That makes the daily insensible perspiration amount 0.5 mL/kg/h or 10 mL/kg/day.[3] Sensible perspiration is visible sweat. The volume varies depending on the surrounding temperature and physiological stress. It was estimated in a patient with rectal temperature of 39°C to account for 600 mL/day (0.3 mL/kg/h). In a clinical setting, sensible perspiration is not generally considered, but may be significant in a patient with severe sepsis.[4] GDFT is a term that describes the protocolled use of cardiac output (CO) and related parameters as end-points for the administration of fluids and/or inotropic therapies with the objective of optimizing organ perfusion with improvement of surgical outcome.[5] The term GDFT was first coined by Shoemaker *et al*. who in 1988 showed that placement of a pulmonary artery catheter (PAC) and attainment of supraphysiologic parameters (i.e., confidence interval >4.5 L/min/m$^2$, $DO_2$ >600 mL/min) were associated with a greater chance of survival in high-risk surgical patient.[6] Conventional parameters such as heart rate, mean arterial blood pressure, central venous pressure, urine output, and arterial lactate level are not reliable in terms of GDFT because they are affected by anesthesia and surgical stress. Advanced hemodynamic monitoring is as follow. First, is noninvasive, the ultrasound/Doppler-based CO monitoring devices such as transesophageal echocardiography (Deltex Medical, Chichester, UK).[7] Second, is invasive which requires arterial line insertion, the pulse wave pressure devices either calibrated such as pulse-induced contour cardiac output (PiCCO) (Pulsion Medical Systems, Munich, Germany) and lithium dilution cardiac output (LiDCO) (LiDCO, London, UK) or uncalibrated such as the FloTrac (Edwards Lifesciences, LLC, CA, USA).[8] The LiDCO and PiCCO used dilution analysis, and both use arterial waveform analysis method, the difference between them and PAC is that both allow for dilution through the systematic or left-sided circulation versus just the right heart. Third, noninvasive, the pulse oximeter plethysmographic waveform analysis (Masimo Rainbow SET Corporation, Irvine, CA, USA) which differs from the arterial pressure waveform by measuring volume rather than pressure changes in both arterial and venous vessels. The "Pleth Variability Index" (PVI) is an automated measure of the dynamic change in the "perfusion index" (PI) that occurs during a respiratory cycle. The PI is the infrared pulsatile signal indexed against the nonpulsatile signal and reflects the amplitude of the pulse oximeter waveform. The PVI correlates closely with the respiratory-induced variation in the plethysmographic and arterial pressure waveforms and can predict fluid responsiveness noninvasively (without inserted arterial line) in the mechanically ventilated surgical patients.[9] Fourth, noninvasive, the finger cuffs which uses the volume clamp method to continuously measure blood pressure and stroke volume from the finger cuff.[10] Fifth, noninvasive, the partial carbon dioxide rebreathing using the reverse Fick principle to calculate CO.[11] Sixth, noninvasive, the transthoracic bioimpedence and bioreactance which exploits the variation in electrical resistance with intrathoracic blood volume during the cardiac cycle.[12] The following case which was reported by Gutierrez *et al*. illustrated that the importance of using GDFT to guide perioperative fluid administration. This is a 63-year-old female patient scheduled for choledochojejunostomy for cholelithiasis and a possible ampullary mass. The FloTrac/Vigileo hemodynamic monitoring was used after inserting arterial line to keep the stroke volume variation between 10% and 13%. The procedure lasted for 4 h. She received a total of 2100 mL of intravenous fluid. Her urine output was 725 mL for the entire procedure. Her vital signs remained stable intraoperatively. If the standard fluid calculation was used for her weight (64.5 kg) following 4-2-1 rule, calculating a deficit per 8 h of fasting and insensitive losses of 10 mL/kg/h plus the total blood loss of 500 mL, the total estimated amount of crystalloids needed

was 6366 mL. However, she received only 2100 mL using GDFT concept with positive impact on enhanced recovery after anesthesia (ERAA).[13] The term ERAA was first coined in 2016.[14] There is intimate relation between ERAA and GDFT. It is well known that with hypervolemia there is increased risk of cellular edema, ileus, postoperative nausea and vomiting, and cardiopulmonary complications.[15] Hypervolemia also releases atrial natriuretic peptide which in turn damages the endothelial wall barrier, namely, glycocalyx (GCX) with subsequent capillary leak syndrome. The endothelial GCX is carbohydrate layer located on the luminal side of healthy vasculature, plays a vital role in vascular permeability by constituting a vascular barrier together with the endothelial cells themselves.[16] There are many animal and human studies on the effects of different fluid items on the GCX with conflicting results.[17-21] Crystalloids and colloids do have different distribution patterns: crystalloids mostly remain in the extracellular space, therefore, they are commonly used for ongoing extracellular losses. If beyond that in case of acute surgical bleeding, isotonic preparations such as hydroxyethyl starch to be considered. However, the decision has to be made on individual basis taking into account the nature of the acute problem and the preexisting illness as well as the economic aspect. Interstitial edema is a relevant clinical problem which affects the outcome. Its incidence is closely related to perioperative fluid therapy. Hypervolemia has to be avoided in elective surgical procedures as it breaks down the integrity of the vascular barrier GCX and causing interstitial edema with bad outcome. We believe that the triple model [Figure 1] described in this editorial plays an important role in the surgical patient outcome.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

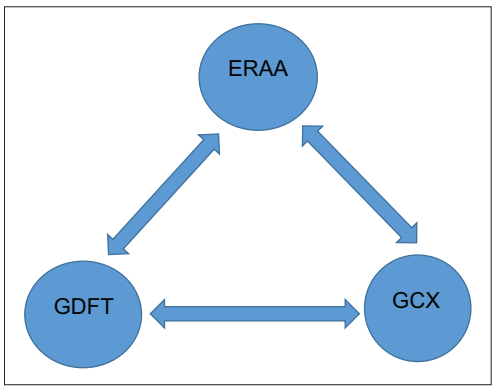


**Figure 1: Enhanced recovery after anesthesia, goal directed fluid therapy, glycocalyx**

**Abdelazeem Eldawlatly**

Department of Anesthesia, College of Medicine, King Saud University, Riyadh, Saudi Arabia.

E-mail: dawlatly@ksu.edu.sa

## References

1. Voldby AW, Brandstrup B. Fluid therapy in the perioperative setting – A clinical review. J Intensive Care 2016;4:27.
2. Lamke LO, Nilsson GE, Reithner HL. Insensible perspiration from the skin under standardized environmental conditions. Scand J Clin Lab Invest 1977;37:325-31.
3. Jacob M, Chappel D, Hofmann-Kefer K, Conzen P, Peter K, Rehm M. Determination of insensible fluid loss. Anaesthesist 2007;56:747-64.
4. Lamke LO, Nilsson G, Reithner L. The influence of elevated body temperature on skin perspiration. Acta Chir Scand 1980;146:81-4.
5. Jhanji S, Pearse RM. The use of early intervention to prevent postoperative complications. Curr Opin Crit Care 2009;15:349-54.
6. Shoemaker WC, Appel PL, Kram HB, Waxman K, Lee TS. Prospective trial of supranormal values of survivors as therapeutic goals in high-risk surgical patients. Chest 1988;94:1176-86.
7. Warnakulasuriya SR, Davies SJ, Wilson RJ, Yates DR. Comparison of esophageal doppler and plethysmographic variability index to guide intraoperative fluid therapy for low-risk patients undergoing colorectal surgery. J Clin Anesth 2016;34:600-8.
8. Tsai YF, Liu FC, Yu HP. FloTrac/Vigileo system monitoring in acute-care surgery: Current and future trends. Expert Rev Med Devices 2013;10:717-28.
9. Marik PE, Monnet X, Teboul JL. Hemodynamic parameters to guide fluid therapy. Ann Intensive Care 2011;1:1.
10. Lakhal K, Martin M, Faiz S, Ehrmann S, Blanloeil Y, Asehnoune K, *et al.* The CNAP™ finger cuff for noninvasive beat-to-beat monitoring of arterial blood pressure: An evaluation in Intensive Care Unit patients and a comparison with 2 intermittent devices. Anesth Analg 2016;123:1126-35.
11. El-Dawlatly AA. Impedance cardiography: Noninvasive measurement of hemodynamics and thoracic fluid content during endoscopic thoracic sympathectomy. Surg Laparosc Endosc Percutan Tech 2005;15:328-31.
12. El-Dawlatly AA. Perioperative bioelectrical impedence analysis in neurosurgery. Middle East J Anaesthesiol 2005;18:575-81.
13. Gutierrez MC, Moore PG, Liu H. Goal-directed therapy in intraoperative fluid and hemodynamic management. J Biomed Res 2013;27:357-65.
14. Eldawlatly A. Is enhanced recovery after anesthesia a synonym to enhanced recovery after surgery? Saudi J Anaesth 2016;10:119-20.
15. Minto G, Scott MJ, Miller TE. Monitoring needs and goal-directed fluid therapy within an enhanced recovery program. Anesthesiol Clin 2015;33:35-49.
16. Becker BF, Chappell D, Jacob M. Endothelial glycocalyx and coronary vascular permeability: The fringe benefit. Basic Res Cardiol 2010;105:687-701.
17. Strunden MS, Bornscheuer A, Schuster A, Kiefmann R, Goetz AE, Heckel K, *et al.* Glycocalyx degradation causes microvascular perfusion failure in the *ex vivo* perfused mouse lung: Hydroxyethyl starch 130/0.4 pretreatment attenuates this response. Shock 2012;38:559-66.
18. Wong YL, Lautenschläger I, Zitta K, Schildhauer C, Parczany K, Röcken C, *et al.* Adverse effects of hydroxyethyl starch (HES 130/0.4) on intestinal barrier integrity and metabolic function are abrogated by supplementation with albumin. J Transl Med 2016;14:60.
19. Yates DR, Davies SJ, Milner HE, Wilson RJ. Crystalloid or colloid for goal-directed fluid therapy in colorectal surgery. Br J Anaesth 2014;112:281-9.
20. Kim TK, Nam K, Cho YJ, Min JJ, Hong YJ, Park KU, *et al.* Microvascular reactivity and endothelial glycocalyx degradation when administering hydroxyethyl starch or crystalloid during off-pump

coronary artery bypass graft surgery: A randomised trial. Anaesthesia 2017;72:204-13.
21. van den Berg BM, Vink H, Spaan JA. The endothelial glycocalyx protects against myocardial edema. Circ Res 2003;92:592-4.

**Access this article online**

**Website:** www.saudija.org

**DOI:** 10.4103/sja.SJA_456_17

**Quick Response Code**



**How to cite this article:** Eldawlatly A. Has goal directed fluid therapy and glycocalyx a role in enhanced recovery after anesthesia? Saudi J Anaesth 2017;11:XX-XX.