Preoperative fasting does not affect haemodynamic status: a prospective, non-inferiority, echocardiography study

L. Muller1,3*, M. Brière1,3, S. Bastide2, C. Roger1,3, L. Zoric1,3, G. Seni2, J.-E. de La Coussaye1,3, J. Ripart1,3 and J.-Y. Lefrant1,3

1 Department of Anesthesiology, Critical Care, Emergency, and Pain, Division Anesthésie Réanimation Douleur Urgences, Centre hospitalier universitaire Caremeau, Place du Pr Debré. 30029 Nîmes, France
2 Department of Biostatistics and Clinical Epidemiology, Centre hospitalier universitaire Caremeau, Place du Pr Debré. 30029 Nîmes, France
3 EA2992 Laboratory of Dysfunction of Vascular Interfaces, Faculté de médecine, Université Montpellier 1, Avenue Kennedy, 30000 Nîmes, France
* Corresponding author: Division Anesthésie Réanimation Douleur Urgences, Groupe Hospitalo-Universitaire Caremeau, CHU Nîmes, Place du Professeur Robert Debré, 30029 Nîmes Cedex 9, France. E-mail laurent.muller27@orange.fr

Editor’s key points

- Clinicians often assume that routine preoperative fasting contributes to hypovolaemia before anaesthesia.
- This study assessed circulating volume by transthoracic echocardiography before and after fasting for at least 8 h.
- There were no significant changes in static or dynamic assessments of circulating volume.
- Routine duration preoperative fasting appears to have no significant effect on circulating blood volume in healthy adults.

Background. The link between preoperative fasting and hypovolaemia remains unclear. We tested the hypothesis that preoperative fasting does not significantly increase the proportion of patients with hypovolaemia according to transthoracic echocardiography (TTE) criteria.

Methods. Patients of ASA status I–III and without bowel preparation were included in a non-inferiority, prospective, single-centre trial. Patients underwent passive leg raising (PLR) test and TTE at admission (Day 0) and after 8 h fasting (Day 1). The primary hypothesis was that an 8 h preoperative fasting does not increase the proportion (margin ¼ 5%) of patients with a positive PLR test (‘functional approach’). The secondary hypothesis was that echocardiographic filling pressures or stroke volume (margin 10%) are not affected by preoperative fasting (‘static approach’).

Results. One hundred patients were included and 98 analysed. After an 8 h fasting, the change in the proportion of responders to PLR was —6.1% [95% confidence interval (CI) ¼ —216.0 to 3.8] of responders to PLR test on Day 0 when compared with Day 1. Because 95% CI was strictly inferior to 5%, there was no significant increase in the proportion of PLR responders on Day 1 when compared with Day 0. The 95% CI changes of static variables were always fewer than 10%, meaning that preoperative fasting induced significantly no relevant changes in static variables.

Conclusion. Preoperative fasting did not alter TTE dynamic and static preload indices in ASA I–III adult patients. These results suggest that preoperative fasting does not induce significant hypovolaemia.

Clinical trial registration. NCT 01258361.

Keywords: blood volume; echocardiography; fasting

Accepted for publication: 4 November 2013

Preoperative fasting before planned anaesthesia is aimed at preventing aspiration and Mendelson’s syndrome.1, 2 As pre-operative fasting is thought to induce dehydration and hypovolaemia, fluid infusion is classically given at the early stage of anaesthesia in order to prevent post-induction hypotension.3, 4 Surprisingly, little evidence corroborates this supposed effect of preoperative fasting.4–7 One study failed to confirm that preoperative fasting had any significant impact on blood volume.5 Another study suggested that blood volume is moderately reduced by fasting and may cause haemodynamic instability.6 The functional deficit (the volume of fluid needed to correct stroke volume after induction of anaesthesia) has been assessed at about 200 ml and could reach 400–600 ml in 15% of patients.6

Transthoracic echocardiography (TTE) can non-invasively assess volaemic status in cardiology outpatients and in critically ill patients.8–10 This can be either assessed by recording transmirtal inflow velocity (static approach) or by a functional test as passive leg rising (PLR).11–13 It was previously demonstrated that ultrasonography techniques are able to detect small variations of blood volume after fluid infusion, ranging from 100 to 300 ml.13–15 Thus, we conducted a prospective study to assess the consequences of preoperative fasting (superior to 8 h period) on haemodynamic status by using TTE in...
patients undergoing abdominal surgery. In order to avoid any influence of anaesthetic drugs on cardiac function or venous return, all measurements were performed the day before surgery and just before anaesthesia induction. The hypothesis of the present study was that the proportion of patients with a positive PLR test before preoperative fasting was non-inferior to that after preoperative fasting (‘functional approach’, primary objective). The same non-inferiority method was applied to TTE static variables (‘static approach’, secondary objective).

Methods

Study design

The present single-centre prospective study was performed in a non-inferiority design to assess the consequences of preoperative fasting on haemodynamic status. The non-inferiority design was more appropriate than the equivalence design because the clinical hypothesis was that preoperative fasting does not worsen the haemodynamic status.

This prospective study was performed from January 26, 2011 to April 13, 2011, following approval by the appropriate Ethics authority (Comité de Protection des Personnes, Nîmes Faculté de médecine de Nîmes, Nîmes, France, no. 2010.12.04). Written informed consent was obtained from all subjects. The study was conducted according to Good Clinical Practice standards and the Helsinki Declaration, and the protocol was registered at ClinicalTrial.gov (NCT 01258361). Our study followed the CONSORT recommendations concerning reporting of non-inferiority trials.16

At admission (Day 0), a dedicated staff anaesthetist (M.B.) met eligible patients in order to explain the design and the aim of the present study.

Inclusion and non-inclusion criteria

Every ASA class I–III17 adult patient with a valid medical insurance and without bowel preparation, admitted for abdominal or gynaecology elective surgery was eligible for the present study. The non-inclusion criteria were: ASA class IV–V patients, the need for bowel preparation, patients <18 yr of age, cardiac arrhythmia, and beta-blockers or vasodilator therapy. Moreover, patients in whom the surgical procedure was planned after 08:30 were not included in order to standardize the duration of preoperative fasting.

Protocol

A TTE was performed the last evening before surgical procedure (17:00 – 20:00) with a PLR test (Day 0). Another TTE with PLR test was repeated before the entry into the operating theatre just before anaesthetic induction (Day 1) (Fig. 1). The procedure and timing for measurements are summarized in Figure 1. Included patients were not allowed to eat or drink after midnight. An oral premedication (hydroxyzin 25 – 50 mg, alprazolam 0.25 – 0.5 mg, or both) was given at 06:00 on the day of surgery. As TTE at Day 1 was performed just before anaesthetic induction, it strictly assesses a preoperative fasting >8 h period without any influence of anaesthetic drugs on cardiac function or venous return.

Measured variables, times of measurement, primary and secondary outcomes

Patient characteristics (age, sex, height, weight, ASA status, type of surgery, and medical history) were recorded at admission. On Days 0 and 1, non-invasive arterial pressure and heart rate were recorded. The fasting duration was recorded.

On Day 0 and Day 1, TTE assessment was performed by an experienced physician (Level 3),9 using a Vivid S6 machine, (GE Healthcare, Pollards Wood, UK). The PLR test was strictly...
standardized by using a semi-recumbent technique (‘functional approach’). A positive response to PLR was defined as a 15% increase in sub-aortic velocity time index (VTI). In order to check whether there was any occult cardiac failure that could influence final results, systolic cardiac function was assessed. Left ventricle ejection fraction (LVEF) was visually assessed (‘Eyeball technique’), automatically quantified by speckle tracking technology, and rounded to 5%. Right ventricle function was assessed by recording tricuspid annular plane systolic excursion (TAPSE) in M-Mode (normal value >16 mm). The E wave (cm s^{-1}), A wave (cm s^{-1}), E-to-A ratio, E wave deceleration time (EDT, ms), and sub-aortic VTI were recorded as usual by pulse wave Doppler in four- and five-chamber apical views. Ea and Aa waves (cm s^{-1}) were recorded by tissue Doppler imaging at the mitral lateral annulus in four- and five-chamber apical views. E/Ea ratio was calculated. VTI indirectly represents stroke volume and then cardiac output, whereas E, A, Ea, Aa wave velocities and derived ratio are related to end diastolic left ventricle pressure (‘static approach’). Finally, we also recorded respiratory variations of inferior vena cava (IVC) diameter. This parameter was analysed by calculating the collapsibility index of the inferior vena cava (cIVC) (%). IVC diameter was recorded on a subcostal view and cIVC was calculated by using the formula: (maximum diameter − minimum diameter)/maximum diameter, as previously reported. Respiratory variations of IVC are correlated to blood volume and central venous pressure in spontaneous breathing patients.

Echocardiography pictures and videos were anonymously stored in order to allow a blinded checking of echocardiographic data by an echocardiography expert. Intra-operator variability was previously validated (= 5%) and not assessed again.

Statistical analysis

Data management was performed in order to check the consistency of all the recorded variables. Data were expressed as mean [standard deviation (so)] or number (percentages). The changes were presented associated with their 95% confidence interval (CI). The primary outcome was the absolute change in the proportion of responder patients from Day 0 to Day 1. The acceptable margin for the change in the proportion of responder patients in a non-inferiority hypothesis between Day 0 and Day 1 was fixed at 5%. The null hypothesis of the study was previously validated (5%).

Incomplete data, this sample size was increased to a total of 100 patients to be included.

All secondary outcomes (comparison of static variables) were analysed with a non-inferiority design, as the primary outcome. The non-inferiority margin was fixed to 10% of relative change because intra- and inter-operator variability for echocardiography measurements was shown to be 5–8%.

All the analyses were performed with SAS 9.2 version (SAS Institute, Cary, NC, USA).

Results

During the study period, 157 patients were screened and 100 patients were included (Fig. 2). Among them, two patients were excluded because surgery was postponed or cancelled. Therefore, 98 patients were analysed. The duration of preoperative fasting was 8 (1) h. Patient characteristics at inclusion are given in Table 1.

Of the 98 analysed patients, there were 16 (16.3%) responders to PLR test on Day 0 and 10 (10.2%) on Day 1. The absolute change in the proportion of responder to PLR between Day 0 and Day 1 was −6.1% (95% CI: −16.0 to 3.8) (Fig. 3). As 95% CI was entirely under the margin of 5%, the preoperative fasting period did not significantly alter the proportion of responders to PLR (P=0.014). As all the 95% CI of the relative changes in static variables between Day 0 and Day 1 (systolic and diastolic blood arterial pressures, static echocardiography variables, and heart rate) were always <10%, the preoperative fasting period did not significantly alter the studied static variables (P<0.0001) (Table 2).

Discussion

In this prospective non-inferiority study including ASA I–III patients for elective abdominal or gynaecology surgery without bowel preparation, a >8 h preoperative fasting did not increase the proportion of responders to PLR test. Moreover, preoperative fasting was not associated with significant changes in intra-cardiac blood flow velocities or VTI recorded by TTE or in respiratory variations of IVC. Finally, arterial pressure and heart rate were not significantly affected by preoperative fasting. All these findings indicate that blood volume, assessed either by a functional test or by static variables, does not decrease after preoperative fasting. As measurements were performed before anaesthesia, the present results are not affected by haemodynamic consequences of anaesthetic drugs.

To the best of our knowledge, this is the first study showing that preoperative fasting did not alter haemodynamic profile before anaesthetic induction. In two previous studies, the consequences of preoperative fasting were studied either by a blood dilution technique or by oesophageal Doppler after anaesthesia induction. These studies suggested a moderate or no impact of fasting on blood volume. However, authors reported two important methodological limitations. In the study using the dilution technique, values of blood volume measured after induction of anaesthesia were compared with normal values obtained in other studies. In the study using
oesophageal Doppler assessment, patient data were collected after general anaesthesia without comparison with stroke volume before anaesthesia. In these studies, a potential impact of anaesthesia induction on blood volume and on vascular tone and cardiac function could not be ruled out. Therefore, in order to avoid this potential bias, the present study was performed without injection of anaesthetic drugs.

Transthoracic echocardiography has been shown to be an accurate and non-invasive tool for haemodynamic assessment of the critically ill patients or cardiologic outpatients.8–10 In critically ill patients, it has been demonstrated that a functional test such as PLR was one of the best ways to predict fluid responsiveness.12 In cardiac patients, intra-cardiac blood flow velocities (‘static’ variables) are commonly used to assess end diastolic left ventricle pressure.81 03 1 Although cIVC is a dynamic parameter, it has been shown to be correlated with central venous pressure28 (a static index) and with blood volume during fluid removal during extra renal replacement therapy.26 Moreover, we recently demonstrated that cIVC ≥ 40% is often associated with fluid responsiveness in spontaneous breathing patients with acute circulatory failure. The superiority of static or functional approach remains debated,32 33 and therefore, both approaches were used in our study. In the present study, whatever the method used, we succeeded to demonstrate no clinically significant change in the studied variables after preoperative fasting, meaning that preoperative fasting does not induce hypovolaemia.5 Thus, our findings could justify a reduction of

---

**Table 1** Patient characteristics at inclusion. BMI, body mass index; SAP, systolic arterial pressure; DAP, diastolic arterial pressure; HR, heart rate; LEVF, left ventricle ejection fraction; TAPSE, tricuspid annular plane systolic excursion, which reflects right ventricle systolic function (normal value > 16 mm)24

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n (%)/mean (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men/women</td>
<td>29 (29%)/71 (71%)</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>53 (15)</td>
</tr>
<tr>
<td>Type of surgery</td>
<td></td>
</tr>
<tr>
<td>Abdominal</td>
<td>76 (76%)</td>
</tr>
<tr>
<td>Gynecological</td>
<td>24 (24%)</td>
</tr>
<tr>
<td>Clinical characteristics</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>24.2 (3.6)</td>
</tr>
<tr>
<td>ASA status</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>53 (53%)</td>
</tr>
<tr>
<td>II</td>
<td>45 (45%)</td>
</tr>
<tr>
<td>III</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>SAP (mm Hg)</td>
<td>132 (19)</td>
</tr>
<tr>
<td>DAP (mm Hg)</td>
<td>78 (11)</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>76 (11)</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>60 (7)</td>
</tr>
<tr>
<td>TAPSE (mm)</td>
<td>22 (2)</td>
</tr>
</tbody>
</table>

---

838
fluid infusion at the time of anaesthesia induction. This could be part of a general policy of reduction in fluids in the perioperative period. Avoiding excessive fluid infusion favourably influences postoperative outcomes.\textsuperscript{33, 43, 5}

The present findings could be interpreted as in contrast to the widely admitted idea that preoperative fasting induces dehydration that itself causes hypovolaemia. There is often confusion between hypovolaemia and dehydration in common practice. A water deficit does not automatically imply hypovolaemia. The physiological fluid loss during fasting can be evaluated to be 0.5 ml kg\(^{-1}\) h\(^{-1}\) because of insensible perspiration and 0.5 ml kg\(^{-1}\) h\(^{-1}\) because of urine output.\textsuperscript{36–38} Thus, the total water deficit after 8–12 h of preoperative fasting is classically evaluated to be from 500 to 1000 ml.\textsuperscript{39–41} This deficit affects not only blood volume, but also every compartment of body. So the part of water deficit affecting blood volume is probably minor or absent. Several studies have suggested that a 10–20 ml kg\(^{-1}\) crystalloids infusion at the beginning of surgery improves postoperative outcomes (in particular prolonged stay) after minor surgery.\textsuperscript{3} \(40, 42\) This favourable effect was attributable to a reduction of symptoms such as thirst, drowsiness, and dizziness,\textsuperscript{3, 40, 42, 43} which are rather symptoms of moderate dehydration than hypovolaemia. In a recent systematic analysis of literature, there was no significant association between postoperative nausea and vomiting and preoperative fasting.\textsuperscript{44} Other data confirm that moderate dehydration is not associated with hypovolaemia. In a study involving 12 healthy volunteers with standardized food intake, a bowel preparation led to a decrease of 1.2 kg in body weight while no significant differences in blood volume or

| Table 2 | Evolution of arterial pressure, heart rate, and echocardiography static parameters from Day 0 to Day 1 (n = 98 patients, no missing data). In a non-inferiority hypothesis (margin = +10%), preoperative fasting was not associated with a significant alteration of static echocardiography parameters or any increase in respiratory variation of the inferior vena cava diameter or E wave deceleration time. Arterial pressure and heart rate were not affected by preoperative fasting. Data are mean (SD) and percentage of variation with 95% CI. D0 = Day 0, day before the surgery (not fasted patient); D1 = Day 1, day of the surgery (fasted patient); \( \Delta \text{D0} \text{D1} \) = variations between Day 0 and Day 1. SAP, systolic arterial pressure; DAP, diastolic arterial pressure; HR, heart rate; VTI, velocity time index; \( \Delta \text{VTI} \), VTI variation between Days 0 and 1; \( \Delta \text{IVC} \), respiratory variation of inferior vena cava diameter; E, E wave velocity. Ea, Ea wave velocity; EDT, E wave deceleration time. |
| Day 0 | Day 1 | \( \Delta \text{D0} \text{D1} \% (95\% \text{CI}) \) |
| SAP (mm Hg) | 132 (19) | 125 (17) | \(-4.9 (\text{-7.0 to -2.8})\) |
| DAP (mm Hg) | 77 (11) | 76 (10) | \(-1.1 (\text{-3.3 to 1.1})\) |
| HR (bpm) | 76 (11) | 72 (11) | \(-3.9 (\text{-6.4 to -1.3})\) |
| VTI before PLR | 17.5 (2.4) | 17.6 (2.6) | \(1.0 (\text{-1.0 to 3.0})\) |
| \( \Delta \text{VTI} \%) | 7.9 (7.1) | 6.4 (6.1) | \(-1.6 (\text{-3.3 to 0.2})\) |
| \( \Delta \text{IVC} \%) | 37 (21) | 33 (20) | \(-4.2 (\text{-8.9 to 0.5})\) |
| E (cm s\(^{-1}\)) | 76.8 (14.4) | 74.0 (14.1) | \(-2.9 (\text{-5.5 to -0.4})\) |
| EDT (ms) | 202 (34) | 204 (32) | \(2.3 (\text{-1.3 to 5.9})\) |
| E/A | 1.23 (0.34) | 1.22 (0.32) | \(1.5 (\text{-2.7 to 5.6})\) |
| E/Ea | 6.14 (1.58) | 6.13 (1.58) | \(1.4 (\text{-2.3 to 5.1})\) |
orthostatic tolerance were demonstrated.65 Finally, the present findings help to discriminate the question of hypovolaemia and the question of dehydration induced by preoperative fasting. Indeed, a systematic fluid infusion (especially colloids) in order to compensate for hypovolaemia induced by preoperative fasting is not necessary. However, as patients may suffer from dehydration or hypoglycaemia, it is still rational to replace pure water deficit that affects the entire fluid phase by dextrose or crystalloids.

Unexpectedly, the present results show a 6.1% decrease of responders from Day 0 to Day 1. This suggests that, at the end of the day, there is potentially more hypovolemia than after a quiet night. We can postulate that, on admission at the end of the afternoon, patients can be more dehydrated by daily activity than after an 8 h sleep period. It can be objected that premedicant drugs may theoretically influence the present results. In particular, the two drugs, especially hydroxyzin, may induce arterial and venous vasodilatation. This vasodilatation could induce ‘relative hypovolaemia’ and therefore a significant increase in the proportion of responders, but we did not observe this. Moreover, premedicant drugs could have also affected arterial pressure or heart rate, but this is not the case. Therefore, our findings did not demonstrate an obvious impact of premedicant drugs on haemodynamic status.

Our study has several limitations. First, TTE does not directly measure blood volume. On the one hand, non-invasive measurement of absolute blood volume is not easy. On the other hand, if TTE does not allow a direct measurement of blood volume, it was demonstrated that acute variations of blood volume during fluid removal by haemodilution are accurately detected and quantified by bedside ultrasonography.26 46 47

Secondly, because the present study included a majority of healthy ‘young’ (<65 yr) adults, these results cannot be extrapolated to elderly, paediatrics, or high-risk patients.

Thirdly, the preoperative fasting duration was 8 h and we cannot extrapolate the present findings for longer fasting duration. However, the present minimal 8 h period is greater than the preoperative fasting recommended in recent international guidelines allowing a water intake until 2 h before anaesthetic induction even in major surgery.7 The present findings strongly support that the risk of dehydration and subsequent hypovolaemia are minor in healthy patients after preoperative fasting.

Conclusion

In conclusion, the present study shows that 8 h preoperative fasting did not alter TTE dynamic and static preload indices in ASA I–III adult patients with no bowel preparation. This suggests that preoperative fasting does not induce significant hypovolaemia.

Authors’ contributions

L.M. designed the study and wrote the manuscript. He also checked all echo data. M.B. performed all echo exams and participated in the redaction of the manuscript. S.B. performed statistical analysis. C.R. revised the manuscript. L.Z. checked English spelling. G.S. was in charge of data management. J.-E.C. revised the manuscript. J.R. revised the manuscript. J.-Y.L. designed, directed the study, and checked the final manuscript.

Acknowledgements

Special thanks to Audrey Ayral, Loubna Elotmani, and Sophie Lloret for their help in data collection.

Declaration of interest

None declared.

Funding

Support was provided solely by institutional, departmental sources, or both.

References


2 American Society of Anesthesiologists Committee. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. Anesthesiology 2011; 114: 495 – 511


Preoperative fasting does not induce hypovolaemia