Endoluminal laser-Doppler measurements of jejunal perfusion in patients undergoing liver transplantation

Received: 12 August 1999
Revised: 22 March 2000
Accepted: 25 May 2000

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Abstract

Patients undergoing liver transplantation are at risk of developing the multiple organ dysfunction syndrome, and attention has been focused on the pathogenetic role of decreased gastro-intestinal mucosal perfusion. The aim of this study was to investigate the use of laser-Doppler flowmetry for determination of jejunal perfusion. In 10 patients an endoluminal laser-Doppler catheter was positioned with the tip in the jejunum for continuous measurements of jejunal perfusion. The anhepatic phase was associated with a progressive decrease in jejunal perfusion to 49 (40/65)% (P < 0.01) of dissection phase value. At the end of surgery the jejunal perfusion had increased to 134 (103/158)% (P < 0.01) of dissection phase jejunal perfusion. The endoluminal laser-Doppler technique was found to be easily applicable for continuous monitoring of jejunal perfusion, and the technique could prove valuable in detecting gastro-intestinal hypoperfusion in patients undergoing liver transplantation.

Keywords
Liver transplantation · Laser-Doppler flowmetry · Splanchnic blood flow · Intestinal mucosa

Abbreviations
MODS Multiple organ dysfunction syndrome · KIU Kallikrein inactivating units · PU Perfusion units · LDF Laser-Doppler flowmetry

Introduction

Patients undergoing liver transplantation are at risk of developing a systemic inflammatory response syndrome, which is usually transient and well-tolerated, but may eventually proceed to the development of the multiple organ dysfunction syndrome (MODS) [33]. This is a serious complication as MODS development after liver transplantation is associated with a prolonged hospital stay and a high mortality [33]. Since Marshall and Meakins in 1986 suggested the gastro-intestinal tract to be the “motor of multiple organ failure”, extensive research has been focused on the role of the gastro-intestinal tract in the pathogenesis of MODS [9, 19, 21]. Attention has been directed to the unique vascular structure of the intestinal villi and the impact of the countercurrent exchange mechanism, which predisposes to villi hypoxia and epithelial damage, when gastro-intestinal mucosal perfusion is decreased [19].

Gastro-intestinal perfusion can be expected to be compromised during the liver transplantation procedure. During the anhepatic phase, clamping of the portal vein and the inferior caval vein interrupts venous return from the abdomen and the lower extremities, decreasing cardiac output and increasing systemic vascular resistance [16]. The use of a veno-venous bypass technique during the anhepatic phase has been suggested for venous decompression, improved haemodynamic stability, improved renal function, and decreased intraoperative blood loss [32], but does probably not result in normal perfusion of the abdomen and lower extremities, as indicated by increased infrahepatic caval vein pressure, decreased cardiac output, and continuous haemocentratin during the bypass period [22, 27].
Table 1 Characteristics of patients and liver transplantation procedure. *APACHE* Acute Physiology and chronic health evaluation, UNOS United network of organ sharing, RBC red blood cell, VVB veno-venous bypass, PBC primary biliary cirrhosis, PSC primary sclerosing cholangitis

<table>
<thead>
<tr>
<th>Age</th>
<th>Indication for transplantation</th>
<th>Preoperaive APACHE II score</th>
<th>UNOS score</th>
<th>Duration donor liver cold ischemia (h/min)</th>
<th>Duration anhepatic phase (h/min)</th>
<th>Duration surgery (h/min)</th>
<th>Intraoperative RBC transfusion (ml)</th>
<th>VVB</th>
<th>VVB flow (l/min)</th>
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</table>

Laser-Doppler flowmetry represents an alternative method for estimation of gastro-intestinal perfusion [1, 5]. In man, laser-Doppler flowmetry has been used to measure gastro-intestinal perfusion in healthy volunteers [10, 14, 18, 20, 29], patients with liver cirrhosis [23, 25, 26], patients undergoing abdominal surgery [2, 3, 5] and patients undergoing cardiac surgery [17, 24, 34].

The aim of the present study was to measure jejunal perfusion in patients undergoing liver transplantation, using an endoluminal laser-Doppler catheter. The general aims were to evaluate whether the method was applicable during clinical liver transplantation, whether it was possible to obtain continuous measurements of jejunal perfusion, and whether monitoring jejunal mucosal perfusion gave additional haemodynamic information, compared with the routine haemodynamic measurements.

Patients and methods

The study was approved by the Human Ethics Committee of the Göteborg University. After informed consent, 10 adult patients undergoing primary OLT were studied. Patient characteristics are shown in Table 1. None of the patients developed postoperative MODS according to the criteria proposed by Spanier and co-workers [33]. Anaesthesia was performed with thiopental sodium, fentanyl citrate and isoflurane in oxygen/air. Suxamethonium chloride and vecuronium bromide were used for muscle relaxation. Two radial artery catheters, a triple-lumen central venous catheter and a pulmonary artery catheter were inserted for continuous monitoring of systemic and pulmonary arterial pressures, blood sampling, and administration of drugs. Aprotinin infusion was started at the beginning of surgery with 1,000,000 KIU (kallikrein inactivating units) during the first 60 min followed by 500,000 KIU every 60 min. A continuous infusion of 3 μg/kg per min dopamine was started at the beginning of surgery and increased as needed to maintain mean arterial pressure. Liver transplantation was performed as an orthotopic liver transplantation using standard technique and veno-venous bypass.

Veno-venous bypass

In nine patients the veno-venous bypass was performed with caval bypass only, and in one patient a combined caval and portal vein bypass was used (Table 1). The veno-venous bypass was performed with the use of a non-occlusive centrifugal pump (model 540 Bio-Medics®, Medtronic, Kerkrade-West, Holland), heparin-coated 3/4 inch diameter shunt tubing (Medtronic, Kerkrade-West, Holland), a 15 Fr. heparin-coated catheter inserted percutaneously into the right internal jugular vein and a 17 Fr. catheter inserted percutaneously into the right or left femoral vein (Medtronic, Anaheim, California, USA). A 16 Fr. heparin-coated insert probe (Carmeda AB, Täby, Sweden) was used for portal vein bypass. Blood drained from the femoral and portal vein catheters was returned to the patient through the catheter in the right internal jugular vein.

Haemodynamic measurements

Mean arterial pressure, mean pulmonary artery pressure, central venous pressure, pulmonary capillary wedge pressure, cardiac index and systemic vascular resistance index were registered at the end of dissection phase, at the end of anhepatic phase (5 min before reperfusion), during reperfusion, (after completion of the hepatic artery anastomosis) and at the end of surgery.

Laser-Doppler catheter

A commercially available, flexible, multichannel, polyethylene catheter (Ch 14, 160 cm, Model 6C, Synectics AB, Stockholm, Sweden) was used in all patients. Two or three of the wall channels were used to pass optical fibres to the distal end of the catheter. The distal end of the catheter was fitted with a plastic knob in which metal guiding tubes were moulded to direct the distal end of the optical fibres perpendicular to the axial line of the catheter. The optical fibres were used for transmitting and receiving laser light using a fibre separation of 0.25 mm. The endoluminal laser-