SHUNT FLOW AND CAVAL PRESSURE GRADIENT DURING VENO-VENOUS BYPASS IN HUMAN ORTHOTOPIC LIVER TRANSPLANTATION


SUMMARY

The routine use of veno-venous bypass during the anhepatic phase of orthotopic liver transplantation is controversial. Decreased shunt flows (1.5–3.0 litre min⁻¹), as reported in the literature, may explain the lack of beneficial effects on outcome. We have studied the influence of bypass flows on caval pressure gradient (CPG) and renal perfusion pressure (RPP) in 45 patients undergoing orthotopic liver transplantation using a portofemoro-subclavian veno-venous bypass system. Mean shunt flow was 3.63 litre min⁻¹. Second-order polynomial regressions best described the relationship between shunt flow and CPG (r = 0.674), RPP (r = 0.727), and cardiac output (r = 0.602). Shunt flows less than 3.0 litre min⁻¹ failed to normalize CPG and RPP, whereas flows greater than 5.0 litre min⁻¹ did not substantially improve haemodynamic state.

KEY WORDS

There is no evidence that extracorporeal veno-venous bypass during orthotopic liver transplantation is beneficial [1] as far as outcome is concerned [2]; however, improvement in such physiological variables as cardiac output and urine production has been demonstrated [2]. Shunt flows described in the literature range from 1.5 to 3.0 litre min⁻¹ in adults [2–4]. It is not known if such flows are sufficient to normalize haemodynamic pressures and thus cardiac output. Therefore, we have assessed the efficacy of shunt flow during portofemoro-subclavian bypass by measuring infra-ICAVP to suprahepatic (SCAVP) caval pressure gradient (CPG) and mean arterial pressure (MAP), from which renal perfusion pressure (RPP = MAP−ICAVP) was derived.

METHODS AND RESULTS

After obtaining local Ethics Committee approval and written, informed consent, we studied the efficacy of portofemoro-subclavian bypass in 45 consecutive adult patients (23 male) undergoing elective or emergency orthotopic liver transplantation. Adults with a body weight less than 50 kg were excluded. Median age was 42 yr (range 19–65 yr) and median body surface area 1.84 m² (range 1.34–2.28 m²). Thirty patients were classified Child B, and 15 Child C; nine were “high urgent” (Eurotransplant urgency code HU) because of fulminant hepatic failure.

General anaesthesia was maintained by a continuous infusion of propofol 40–60 µg kg⁻¹ min⁻¹ and fentanyl 0.1–0.3 µg kg⁻¹ min⁻¹ with 0.4–0.6 % isoflurane. Fluid administration, blood transfusion and catecholamine support were adjusted to produce a normal haemodynamic state with a mean arterial pressure > 60 mm Hg, central venous pressure 5–10 mm Hg, cardiac index > 2.5 litre min⁻¹ m⁻², haemoglobin concentration 10 g litre⁻¹ and PCV 30 %. All patients received low-dose dopamine 3–5 µg kg⁻¹ min⁻¹. In six urgent cases, adrenaline 0.1–0.3 µg kg⁻¹ was given to maintain cardiac output. ICAVP was measured via the right femoral vein.

Before operation, the left femoral and subclavian veins were cannulated with 7-mm single lumen catheters (LAUB percutaneous cannulation set, Cook Europe, Mönchengladbach, Germany) for portofemoro–subclavian bypass. Shunt flows were initially rendered optimum by adjusting the pump speed to the greatest possible flow rate before collapse of the tubing.

When shunt flow reached a steady state during the anhepatic phase, haemodynamic measurements were performed. Cardiac index (CI), oxygen transport (Do₂) and oxygen consumption (Vo₂) were derived using the usual equations. Statistical analysis was performed by linear and second order polynomial regression analysis. The significance of sample correlation coefficient (r) was calculated using a two-tailed t test. P < 0.05 was considered significant.

Mean shunt flow was 3.63 (SEM 0.20) litre min⁻¹ (range 0–6.6 litre min⁻¹). In one patient it was not possible to establish a shunt flow because of air entrainment into the portal cannula. Mean haemo-
subclavian and femoral veins for portofemoro-

percutaneous cannulation set for catheterization of

Our study has shown that the use of a 7-mm

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P < 0.05). ICAVP and 

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BRITISH JOURNAL OF ANAESTHESIA

the subclavian and femoral veins for portofemoro-

globein concentration was 9.9 (1.5) g litre⁻¹ before

onset of veno–venous bypass and 10.2 (0.26) g litre⁻¹ during shunt; PCV was 29.2 (0.69) % and 30.0

(0.98) %, respectively.

During veno–venous bypass, CI was 3.82 (0.16)
litre min⁻¹ m⁻² (4.41 (0.2) litre min⁻¹ m⁻² before bypass); MAP was 74.9 (2.3) mm Hg (77.7 (1.9) mm

Hg before bypass); CPG was 6.8 (0.8) mm Hg (7.5

(1.2) mm Hg before bypass) RPP was 56.4 (2.7) mm

Hg (62.4 (1.9) mm Hg before bypass); PAP was 17.5

(0.7) mm Hg (18.1 (0.9) mm Hg before bypass),

PAOP was 8.9 (1.2) mm Hg (11.7 (1.0) mm Hg

before bypass); DO₂ was 491.6 (26.7) ml min⁻¹ m⁻²

(549.2 (26.5) ml min⁻¹ m⁻² before bypass) and VO₂

was 115.7 (7.8) ml min⁻¹ m⁻² (124.3 (3.9) ml min⁻¹

m⁻² before bypass).

The relationship between shunt flow and CPG was

categorized best by a second-order polynomial

regression

\( y = 22.78 - 7.19x + 0.68x^2 \); \( r = 0.674, 

P < 0.0005 \). Taking into account the patient's body

surface area by correlating the CPG and RPP to

shunt flow index, an even better correlation with

CPG (\( r = 0.66, P < 0.0005 \)) and RPP (\( r = 0.744, 

P < 0.0005 \)) was found (fig. 1).

As far as the relationship between shunt flow and CPG or RPP was concerned, we found no differences

between patients with chronic and acute hepatic

failure.

The relationship between shunt flow and DO₂ was

categorized by a second-order polynomial

regression

\( y = 98.11 + 3.72x - 0.13x^2 \); \( r = 0.329, 

P < 0.05 \). ICAVP and \( \dot{V}O_2 \) showed an inverse

relationship (second-order polynomial regression \( y = 38.11 + 3.72x - 0.13x^2 \); \( r = 0.329, P < 0.05 \)).

COMMENT

Our study has shown that the use of a 7-mm

percutaneous cannulation set for catheterization of the subclavian and femoral veins for portofemoro-

venous bypass ensures large shunt flows (mean

3.6 litre min⁻¹). The data indicate that CPG and

hence RPP were dependent on shunt flow and that

this relationship was almost linear for a shunt flow

less than 3 litre min⁻¹. The correlation between

shunt flow and CO (\( r = 0.602, P < 0.0005 \)) in our

patients was good, as were the correlations between

shunt flow and RPP (\( r = 0.675, P < 0.0005 \)) or CPG

(\( r = 0.571, P < 0.0005 \)), respectively. ICAVP and

duce CPG and RPP were dependent mainly on

shunt flow and thus mirrored the efficacy of blood

drainage from the portocaval to the superior caval

venous system.

If orthotopic liver transformation is performed

without veno–venous bypass RPP is usually small,

leading to intraoperative oliguria [1]. Estrin and

colleagues [5] found a mean RPP between 40 and 49

mm Hg in 26 adult patients without veno–venous

bypass and the CPG was 36–37 mm Hg. In that

group of patients, mean arterial pressure during the

anhepatic phase was surprisingly increased and even

greater (82–98 mm Hg) than in the pre-anhepatic

phase (81–91 mm Hg), probably because of fluid and
catecholamine administration.

Adverse haemodynamic changes associated with
cross clamping of the caval vein can be overcome by

such as fluid overload. Even with veno–venous

bypass, this remains a major problem and has led to

the institution of intraoperative continuous arterio-

venous haemofiltration in some centres [6].

Our study shows that shunt flows less than 3.0 litre

min⁻¹ failed to normalize CPG and RPP. Our data

don't show that the relationship between shunt flow index

and CI, CPG and RPP behaved in a curvilinear

fashion and that an increase in shunt flows led to an

increase in RPP and a decrease of CPG linearly when

shunt flows were decreased (< 3.5 litre min⁻¹) but

optimized CPG (< 5 mm Hg) and RPP (> 60 mm

Hg) to only a small extent when shunt flows were great (> 5 litre min⁻¹).