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ORIGINAL ARTICLE

High incidence of thrombotic complications early after liver transplantation for familial amyloidotic polyneuropathy

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Summary

Early thrombotic complications are critical causes of in-hospital morbidity after orthotopic liver transplantation (OLT), potentially culminating in graft loss. The aim of this study was to retrospectively analyse these complications, trying to identify associated independent risk factors. This retrospective analysis included 223 OLTs performed on 213 patients, in a 30-month period. Eighty-six OLTs were performed on familial amyloidotic polyneuropathy (FAP) patients. Preoperative details (primary diagnosis and Child-Turcotte-Pugh classification, when applicable), surgical features (including type of arterial reconstruction), postoperative variables and outcome were analysed. The observation period ended 30 days post-OLT, until discharge or in-hospital death. Early thrombotic complications were diagnosed in 16 cases (7.2%), affecting mainly FAP patients ($n = 12$). Hepatic artery thrombosis (HAT) was the most frequent early thrombotic event ($n = 12$): incidence in FAP patients 11.6% ($n = 10$) versus incidence in non FAP patients 1.5% ($n = 2$), $P = 0.001$. By logistic regression analysis, FAP turned out to be an independent risk factor for early thrombotic complications, and specifically for HAT. The type of arterial reconstruction and other analysed surgical and medical factors did not influence early HAT occurrence. In conclusion, FAP was identified in this study as an independent risk factor for early HAT, a new datum not yet described in the literature.

Introduction

Orthotopic liver transplantation (OLT) is a valuable treatment in several end-stage liver diseases. It is also a valid option for patients with familial amyloidotic polyneuropathy (FAP), aiming to halt disease progression [1–3]. FAP is endemic in Portugal and is presently linked to an increase in the donor pool, in the so-called domino (sequential) liver transplantation [4,5].

Since the time the first OLT was performed in our centre in 1992, there have been marked improvements in surgical technique, anaesthetic management, immunosuppressive regimen and the medical care of these patients. However, early postoperative thrombotic complications, particularly hepatic artery thrombosis (HAT), remain critical causes of in-hospital morbidity, potentially culminating in acute graft loss [6,7].

In our centre, several cases of early thrombotic complications seemed to occur with no apparent postsurgical anatomical or technical cause. Also, these complications appeared to affect FAP patients in particular, which looked like a paradox, as globally OLT in these patients is considered technically simpler (as their liver architecture is normal) [8]. The aim of this retrospective study was to characterize and analyse early postoperative thrombotic events in our centre, and identify independent risk factors for these complications. Special attention was given to the FAP group of patients.

Patients and methods

The study was retrospective and analysed patients submitted to OLT between January 2005 and June 2007 (30 months). There were no exclusion criteria. In this period, 223 OLTs (205 primary transplantations and 18 retransplantations) were performed on 213 patients, including 73 women and 140 men; overall mean age was 45.0 years (range, 21–69 years old).

Indications for primary OLT are listed in Table 1. One hundred and seventeen patients had liver cirrhosis, 45 with associated hepatocellular carcinoma and 72 with end-stage liver disease. Child-Turcotte-Pugh (CTP) classification was used as a severity index for patients with liver cirrhosis. These patients were distributed as follows: CTP class A, $n = 22$; CTP class B, $n = 33$; CTP class C, $n = 62$.

The FAP was a major indication for primary OLT ($n = 78$, 38.1%) and eight out of the 18 retransplantations were performed on patients with underlying FAP disease, thus making a total of 86 transplantations in FAP patients. The major indication for retransplantation was HAT ($n = 9$, 50.0%), followed by chronic graft rejection ($n = 3$, 16.7%). Domino (sequential) OLT (using grafts from FAP patients) was performed on 48 patients. There were three OLTs using reduced liver grafts (two split-liver and one living-donor transplantation).

The Liver Transplant Centre was responsible for the selection of transplant candidates and for their follow up after discharge from intensive-care unit (ICU). All the OLTs included in this study were carried out by anaesthetists and surgeons from the same single unit.

Deceased donor OLTs were performed using the piggyback technique, with preservation of the inferior vena cava. In domino OLTs, a modified piggyback technique as originally described by Pena *et al.* [9], was used, allowing FAP hepatectomy to be performed with inferior vena cava preservation. The order of reconstruction of the structures was as follows: hepatic veins, portal vein, hepatic artery and biliary duct. For arterial reconstruction, a magnifying glass was used. Anastomosis between donor and recipient's hepatic artery (or sometimes, coeliac trunk) was usually performed, with a running suture using prolene 6/0 or 7/0, and this was taken as the standard arterial anastomosis. When anastomosis to recipient's hepatic artery or coeliac trunk was not feasible, aortic conduits, using a donor iliac artery interposition graft, were used for arterial reconstruction. Complex arterial reconstruction (such as back-table reconstruction of accessory right or left hepatic arteries, multiple anastomoses) was necessary in case of some patients.

Table 1. Indications for primary OLT ($n = 205$).

	Indication	No. (%) of procedures
Metabolic disease	Familial amyloidotic polyneuropathy	78 (38.1)
Malignancy	Hepatocellular carcinoma	45 (21.9)
	Other	4
End-stage liver disease	Alcoholic liver disease	24 (11.7)
	Chronic hepatitis C	23 (11.2)
	Cholestatic liver disease	6
	Chronic hepatitis B	5
	Autoimmune hepatitis	5
	Cryptogenic cirrhosis	5
	Other	4
Acute liver failure	Acute viral hepatitis	2
	Acute toxic hepatitis	1
Other		3

Intraoperative blood transfusion requirements were determined by serial blood tests, including haemoglobin level and haematocrit, prothrombin time, fibrinogen level and platelet count. Packed red blood cells (RBCs) were administered to maintain haematocrit levels at 30%. Fresh-frozen plasma (FFP) was administered when haemostasis was clinically insufficient, or prothrombin time was over 20 s.

After surgery, blood testing (including haemogram, liver function indices and serum lactate level) was undertaken at ICU admission, twice a day in the first 2 days and then daily, and whenever clinically required. A postoperative protocol for ultrasound Doppler screening was not formally established in our centre. In practice, Doppler ultrasonography of the liver was routinely performed once a day, every 24 h during the first two postoperative days and for the majority of patients also during the third postoperative day. Subsequently, Doppler ultrasonography was performed whenever vascular complications were suspected, depending on clinical and laboratorial findings. Urgent surgical revascularization was attempted in highly suspected cases of HAT, based on Doppler ultrasonography findings and clinical setting. When Doppler ultrasonography findings were equivocal, abdominal CT scan, angiography, or both were performed.

Low-molecular-weight heparin (LMWH) therapy was routinely used for early thrombotic event prophylaxis. This was started as soon as a normalization trend of coagulation tests (including factor V) was registered, in the absence of clinical signs of haemorrhagic diathesis. A thrombotic event was defined as thrombosis involving the hepatic artery, portal vein, hepatic veins or inferior vena cava, confirmed by angiography or surgery. Early HAT was defined as the occurrence of thrombosis within the

first 30 days after OLT [10]. The observation period ended 30 days post-OLT, until discharge or in-hospital death.

The following perioperative variables were analysed: preoperative details (primary diagnosis and CTP classification, when applicable); surgical or intraoperative details (retransplantations, domino procedures, reduced liver grafts, type of arterial reconstruction, operative time, and RBCs and FFP units transfused); postoperative details and outcome (severity scores APACHE II and SAPS II on ICU admission, laboratory data, ICU stay, mechanical ventilation time, dialysis requirement and mortality). Analysed laboratory data included: haematocrit, haemoglobin, alanine aminotransferase (ALT), aspartate aminotransferase (AST) and serum lactate levels. For haematocrit and haemoglobin, levels at ICU admission (early postoperative) were analysed. For ALT, AST and serum lactate, levels at ICU admission and maximum values with respective time after surgery were considered. Data were also assessed on urgent surgical re-intervention, day of prophylactic anticoagulation therapy introduction and Doppler ultrasonography findings suggestive of thrombotic events.

Data are expressed as average and standard deviation. For comparative analysis, parametric (Student *t*-test, for numeric variables) and nonparametric tests (Chi-squared and Mann–Whitney tests, for categorical variables and whenever normality could not be found) were used. Comparison between variables with a small sample size ($n < 10$) was not considered. To establish dependence between variables, logistic regression analysis was performed (backward LR) and a goodness-of-fit test (Hosmer-Lemeshow) was used to assess the fit of the logistic regression model. The dependent variables considered were postoperative early thrombotic events and early HAT. A *P*-value <0.05 was considered statistically significant. The statistical program used was SPSS for Windows, version 13.0 (SPSS Inc., Chicago, IL, USA).

Results

Early thrombotic events were diagnosed in 16 cases (incidence 7.2%), affecting mainly FAP patients: incidence in FAP patients 14.0% ($n = 12$) versus incidence in non FAP patients 2.9% ($n = 4$), $P = 0.002$.

Hepatic artery thrombosis was the most frequent early thrombotic event ($n = 12$, 5.4%): incidence in FAP patients 11.6% ($n = 10$) versus incidence in non-FAP patients 1.5% ($n = 2$), $P = 0.001$. Portal vein thrombosis (three cases, two in FAP patients) and thrombosis of suprahepatic vena cava (one case in non-FAP patient) represented the remaining cases of early thrombotic events.

Early HAT

As referred to previously, early HAT incidence was 5.4% ($n = 12$) and it was significantly higher in FAP patients (11.6%). Early HAT showed peak incidence on the second day post-OLT (there were three cases on day 1, five cases on day 2, two cases on day 3 and only two cases after day 4). The majority of patients ($n = 8$) were not under prophylactic LMWH therapy at the time of HAT diagnosis.

Early HAT presented with no clinical signs or symptoms (identified in routine Doppler ultrasonography) in seven cases. Elevation of serum transaminases following initial decreasing trend was registered in nine cases. Three patients with early HAT did not show any clinical or laboratory changes. Routine Doppler ultrasonography showed high sensitivity (91.7%, 1 false-negative in 12 cases) and specificity (78.6%, three false-positives in 14 suspected cases) for early HAT diagnosis.

Urgent retransplantation because of acute allograft dysfunction was necessary in four patients with early HAT. Two of these patients ultimately died because of early HAT. Eight patients underwent revascularization surgery, with successful outcomes.

In 168 OLTs (75.3%), the standard method for arterial reconstruction was used. In eight of these OLTs (4.8%), early HAT occurred. Early HAT incidence was similar when a donor's hepatic artery or donor's coeliac trunk was used in arterial anastomosis: 4.6% (7/153 cases) versus 6.7% (1/15 cases), respectively ($P = 0.719$). Aortic conduits were used in 32 OLTs (14.3%), 12 of which in retransplantations. When an aortic conduit was used for arterial reconstruction, early HAT incidence was 9.4% ($n = 3$). Compared with early HAT incidence using standard arterial anastomosis (4.8%), a significant difference could not be found ($P = 0.297$). Complex arterial reconstruction was performed on 23 OLTs, in which one episode of early HAT was observed (4.4%).

A comparison of preoperative and intraoperative details between patients with and without early HAT is presented in Table 2a. It can be observed that there was no significant difference in the type of arterial reconstruction, or in intraoperative RBCs or FFP transfusions between both the groups. Remarkably, all three OLTs using reduced liver grafts were complicated by early HAT (all cases in FAP recipients). In Table 2b, a comparison of postoperative details and early outcome between patients with and without early HAT is presented. Notably, early postoperative haematocrit and haemoglobin levels were similar between patients with and without early HAT.

Analyzing the whole sample by logistic regression, primary diagnosis of FAP was the only independent factor

Table 2. (a) Preoperative and intra-operative data and (b) postoperative data and early outcome in patients with and without early HAT.

Parameter	Group with early HAT (n = 12)	Group without early HAT (n = 211)	P
(a)			
Age (years)	36.8 (±8.9)	45.8 (±12.3)	0.013
FAP patients	83.3% (n = 10)	36.0% (n = 76)	0.001
Cirrhosis CTP class A	8.3% (n = 1)	10.0% (n = 21)	NS
Cirrhosis CTP class B	0.0% (n = 0)	15.6% (n = 33)	NS
Cirrhosis CTP class C	8.3% (n = 1)	28.9% (n = 61)	NS
Re-transplanted patients	8.3% (n = 1)	8.1% (n = 17)	NS
Operative time (h)	5.9 (±1.2)	6.7 (±1.3)	NS
Reduced liver-grafts	25.0% (n = 3)	0.0% (n = 0)	NC
Standard arterial anastomosis	66.7% (n = 8)	75.8% (n = 160)	NS
Aortic conduits in arterial reconstruction	25.0% (n = 3)	13.7% (n = 29)	NS
Complex arterial reconstruction	8.3% (n = 1)	10.4% (n = 22)	NS
RBCs transfused in the operating room (U)	6.0 (±6.0)	7.0 (±6.3)	NS
FFP transfused in the operating room (U)	20.4 (±11.6)	24.3 (±14.5)	NS
(b)			
APACHE II (ICU admission)	9.2 (±4.2)	11.8 (±7.2)	NS
SAPS II (ICU admission)	20.9 (±13.9)	27.3 (±17.1)	NS
Haemoglobin (ICU admission) (g/dl)	10.5 (±1.1)	10.7 (± 1.8)	NS
Haematocrit (ICU admission) (%)	31.2 (±3.7)	31.6 (± 5.5)	NS
Serum lactate (ICU admission) (mmol/l)	7.6 (±3.2)	6.8 (±3.9)	NS
AST (peak value) (UI/l)	4310 (±3820)	1525 (±1874)	<0.001
ALT (peak value) (UI/l)	4178 (±4738)	1075 (±1075)	<0.001
ICU stay (days)	13.4 (±20.2)	5.1 (±7.0)	0.001
Mechanical ventilation (days)	7.9 (±21.1)	1.3 (±6.0)	0.003
Dialysis requirement	25.0% (n = 3)	8.1% (n = 17)	0.046
Mortality	16.7% (n = 2)	3.3% (n = 7)	NC
ICU readmissions	50.0% (n = 6)	10.0% (n = 21)	<0.001

FAP, familial amyloidotic polyneuropathy; CTP, Child-Turcotte-Pugh; RBCs, packed red blood cells; FFP, fresh-frozen plasma; NS, not significant; NC, not considered; ICU, intensive-care unit; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

associated to early HAT (P = 0.006, 95.0% CI 0.024–0.527). The result of the Hosmer-Lemeshow test P value for this logistic regression analysis was 0.765.

Other early thrombotic events

Portal vein thrombosis occurred in three cases (incidence 1.4%): one case of main portal vein thrombosis in a FAP patient, following retransplantation; and two cases of right portal vein partial thrombosis, in a FAP patient and in a cirrhotic patient. Urgent surgical re-intervention with thrombectomy was performed in the main portal vein thrombosis. Nevertheless, the patient ultimately died because of septic shock in postoperative period. A conservative approach was chosen for the two asymptomatic patients with partial right portal vein thrombosis, with a favourable outcome.

Thrombosis of suprahepatic vena cava occurred in one patient (incidence 0.5%) and resulted from recurrence of Budd-Chiari syndrome. Doppler ultrasonography and angio-CT diagnosed inferior vena cava thrombosis and urgent retransplantation was successful.

Considering all early thrombotic events (16 cases), by logistic regression, primary diagnosis of FAP remained the only independent predicting factor identified (P = 0.008, 95.0% CI 0.046–0.627). The result of the Hosmer–Lemeshow test P-value for this logistic regression analysis was 0.786.

FAP group analysis

In Table 3, the main differences between FAP and non-FAP groups of patients are presented. It can be observed that FAP patients were younger, had shorter operative times, less RBCs and FFP units consumed during surgery, and lower severity scores (APACHE II and SAPS II) on ICU admission. Remarkably, early postoperative haematocrit and haemoglobin levels were similar in both groups. It can also be noticed that aortic conduits were more frequently used in FAP patients (23.3%, n = 20). However,

Table 3. Comparative analysis between FAP and non FAP groups of patients.

Parameter	FAP group (n = 86)	Non-FAP group (n = 137)	P
Age (years)	35.6 (±7.9)	51.4 (±10.6)	<0.001
Operative time (h)	6.2 (±1.2)	7.0 (±1.3)	<0.001
RBCs transfused in the operating room (U)	4.5 (±4.7)	8.6 (±6.7)	<0.001
FFP transfused in the operating room (U)	19.7 (±11.9)	26.7 (±15.1)	<0.001
Aortic conduits in arterial reconstruction	23.3% (n = 20)	8.8% (n = 12)	0.003
Complex arterial reconstruction	12.8% (n = 11)	8.7% (n = 12)	NS
APACHE II (ICU admission)	9.1 (±6.7)	13.3 (±6.8)	<0.001
SAPS II (ICU admission)	20.1 (±16.8)	31.3 (±15.6)	<0.001
Haemoglobin (ICU admission) (g/dl)	10.8 (±1.8)	10.5 (± 1.7)	NS
Haematocrit (ICU admission) (%)	31.9 (±5.7)	31.3 (± 5.3)	NS
Early thrombotic events	14.0% (n = 12)	2.9% (n = 4)	0.002
Early HAT	11.6% (n = 10)	1.5% (n = 2)	0.001

RBCs, packed red blood cells; FFP, fresh-frozen plasma; ICU, intensive-care unit; HAT, hepatic artery thrombosis; NS, not significant.

the majority (n = 17) of FAP patients with aortic conduits did not have a thrombotic complication (there were only three cases of aortic conduit thrombosis). Actually, most of early HAT in FAP patients (n = 6) occurred after standard arterial anastomosis. Within the FAP group, there was not any significant difference in intraoperative RBCs and FFP transfusions and also in early postoperative haematocrit and haemoglobin levels between patients with and without HAT. By multivariate analysis within FAP patients, none of the factors analysed was independently associated to early thrombotic events (or, specifically, to early HAT).

Remarkably, it became evident that the incidence of early HAT in FAP patients was nearly constant during the study period, with roughly 12% of FAP patients affected each year (3/26 in 2005, 4/35 in 2006 and 3/25 in the first semester of 2007). A significant difference in blood components administration stood out when comparing the first 12 months (2005) with the next 18 months (2006 and the first semester of 2007). The trend was to administer less intraoperative RBCs and FFP units: RBCs units, 9.9 (±7.1) vs. 6.2 (±5.6), $P < 0.001$; FFP units, 32.8 (±17.2) vs. 21.0 (±10.3), $P < 0.001$. There was also a trend to an earlier introduction of prophylactic LMWH therapy: postoperative day of first administration of prophylactic LMWH, 3.6 (±3.9) vs. 2.5 (±2.0), $P = 0.042$. Particularly within the FAP group, these changes in intraoperative blood transfusions and also in prophylactic LMWH introduction along the study period also achieved statistical significance.

Discussion

In this retrospective study, the most important finding was the outstanding incidence of early thrombotic events, particularly HAT, in the FAP population. Portugal represents a major cluster of FAP type 1 (which is particularly severe), first described by Corino de Andrade [1,11], and the majority of published work agrees that liver transplantation halts disease progression [1–3]. Thus, the number of FAP transplanted patients in all three Portuguese liver transplant centres has progressively expanded [1,12].

In this study, the incidence of early HAT in FAP patients was 7.7-fold higher, compared to non-FAP patients. In multivariate analysis, diagnosis of FAP was independently associated to an increased risk of early HAT. This association between FAP and early HAT after OLT is a new datum, not yet described in the literature. Furthermore, this happens even though liver architectural structure and biochemical functions are apparently normal in these patients, except for mutant transthyretin synthesis [8,13]. An association between early HAT and other preoperative variables, such as preoperative severity index (represented by CTP classification), could not be found.

In the literature, HAT is the most common early thrombotic event following OLT, often culminating in acute graft loss [6,7]. The incidence of early HAT in this study was 5.4%, a higher value when compared with other series evaluating adult patients. Stange *et al.* [7], described an incidence of 1.2% in a series of 1192 OLTs, and Silva *et al.* [14], an incidence of 1.8% in a series of 1257 OLTs. In this study, in patients without FAP, early HAT incidence was 1.5%, similar to the referred series. Therefore, the underlying cause of the higher incidence of early HAT was the significant number of FAP patients in our sample (early HAT incidence in the FAP-group, 11.6%).

Generally, OLT in FAP patients is technically simpler, as their liver structure and anatomic features are normal [8,13]. This resulted in shorter operative time and fewer

intraoperative blood transfusion requirements for these patients. Besides, the type of arterial reconstruction did not significantly influence the incidence of early HAT in FAP patients and most FAP patients with early HAT had been submitted to standard arterial anastomosis. These data suggest that the higher incidence of early HAT in the FAP population cannot be justified based on the technical factors analysed. It may rather be under the influence of unknown medical factors to some extent.

Earlier, surgical technique was thought to be the most important risk factor for HAT [14,15]. Complex arterial reconstructions of donor's aberrant hepatic arteries and multiple arterial anastomoses are established predisposing factors for early HAT [6]. The use of an aortic conduit was also found to predispose the development of early HAT in several studies [14,16,17]. In our sample, complex arterial reconstructions and the use of aortic conduits were not related to early HAT occurrence. Split or reduced liver grafts have also been linked to early HAT [6], although not confirmed in large published series [18,19]. In this study, all three OLTs using reduced liver grafts were complicated by early HAT (remarkably, all cases in FAP recipients).

In recent literature, several medical factors have been proved to be aetiologically linked to early HAT [10,14]. Described medical factors include higher intraoperative RBCs and FFP unit use [10,14], higher early postoperative haematocrit and haemoglobin levels [14], genetic predisposition of recipients to hypercoagulability states [10,20], transplantation across ABO blood group [20], among others. In this study, intraoperative transfusion requirements and early postoperative haematocrit and haemoglobin levels were similar for patients with and without early thrombotic events (also in the FAP group). Furthermore, despite lower intraoperative use of RBCs and FFP units throughout the study period and also an earlier introduction of prophylactic LMWH therapy, there was no change in early thrombotic events incidence.

In this study, patients with early HAT had increased morbidity (prolonged mechanical ventilation and ICU stay, higher incidence of renal failure requiring dialysis and increased ICU readmissions), although they were globally younger (as the majority were FAP patients) and tended to have lower severity scores on ICU admission. Mortality after early HAT was 16.7%, similar to that reported in larger series [7,14].

The value of Doppler ultrasonography of the implanted allograft as a non invasive and readily available technique in the identification of early vascular complications has been largely accepted [21–23], with the potential of identifying HAT when it has not yet been suggested on clinical grounds [22,24]. The authors also found that routinely performed Doppler ultrasonography was highly sensitive (91.7%) and specific (78.6%) for early HAT diagnosis, thereby preventing acute graft loss and avoiding retransplantation.

Portal vein thrombosis is a rare post-OLT complication (incidence, 0.3–2.2%) [25], classically associated to technical factors [6] and is most detrimental in the early postoperative period. Remarkably, in this study, two out of three portal vein thrombotic complications occurred in FAP patients. Vena cava thrombosis is also a rare complication post-OLT, usually associated to technical factors or resulting from recurrence of Budd-Chiari syndrome [6]. We had a case of recurrence of Budd-Chiari syndrome, and in spite of the high mortality rate associated to this condition (50.0–75.0%) [6], urgent retransplantation was successful.

Higher incidence of early thrombotic events, particularly HAT in FAP patients, brings to focus the need for further physiopathological investigation and specific prevention strategies for this population. Earlier introduction of prophylactic LMWH therapy and reduction in intraoperative transfusions did not influence the incidence of thrombotic complications in this study. In our centre, additional preventative measures for the patients are presently under consideration. These include initiation of prophylactic aspirin on the first postoperative day, and protocol Doppler ultrasonography of the liver every 12 h in the first week and every 24 h in the second week, previously reported in paediatric patients [24] as accurate in early detection of HAT, allowing graft-salvage and thereby reducing the need for retransplantation. In this study, the cause for higher incidence of early thrombotic events in FAP patients could not be detected. More studies aiming to clarify this phenomenon are needed.

Authorship

MB and PM: performed the main role, designing the study, collecting and analysing the data and writing the article. AF, AM, LM and EB: contributed to study design, results analysis and writing the article. AM: also contributed on data collection.

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References

1. Monteiro E, Freire A, Barroso E. Familial amyloid polyneuropathy and liver transplantation. *J Hepatol* 2004; **41**: 188.
2. Monteiro E, Perdigoto R, Furtado AL. Liver transplantation for familial amyloid polyneuropathy. *Hepatogastroenterology* 1998; **45**: 1375.

3. Suhr OB, Hernelius G, Friman S, Ericzon B-G. Liver transplantation for hereditary transthyretin amyloidosis. *Liver Transpl* 2000; **6**: 263.
4. Schmidt HH-J, Nashan B, Propsting MJ, *et al.* Familial amyloidotic polyneuropathy: domino liver transplantation. *J Hepatol* 1999; **30**: 293.
5. Nunes F, Valente M, Pereira R, Amil M. Domino liver transplant: influence on the number of donors and transplant coordination. *Transplant Proc* 2004; **36**: 916.
6. Mueller AR, Platz KP, Kremer B. Early postoperative complications following liver transplantation. *Best Pract Res Clin Gastroenterol* 2004; **18**: 881.
7. Stange BJ, Glanemann M, Nuessler NC, Settmacher U, Steinmuller T, Neuhaus P. Hepatic artery thrombosis after adult liver transplantation. *Liver Transpl* 2003; **9**: 612.
8. Lewis WD. Liver transplant and familial amyloidotic polyneuropathy. *Liver Transpl* 2002; **8**: 1085.
9. Pena JR, Barroso E, Martins A, Andrade JR, Pereira JP. Sequential whole liver transplant resected as piggy-back from FAP patients (abstract). *Liver Transpl* 2002; **8**: C.
10. Pastacaldi S, Teixeira R, Montalto P, Rolles K, Burroughs AK. Hepatic artery thrombosis after orthotopic liver transplantation: a review of nonsurgical causes. *Liver Transpl* 2001; **7**: 75.
11. Andrade C. A peculiar form of peripheral neuropathy. *Acta Psych Neurol Scand* 1951; **26**: 251.
12. Herlenius G, Wilczek HE, Larsson M, Ericzon B-G. Ten years of international experience with liver transplantation for familial amyloidotic polyneuropathy: results from the familial amyloidotic polyneuropathy world transplant registry. *Transplantation* 2004; **77**: 64.
13. Ericzon BG, Larsson M, Herlenius G, Wilczek HE. Report from the Familial Amyloidotic Polyneuropathy World Transplant Registry (FAPWTR) and the Domino Liver Transplant Registry (DLTR). *Amyloid* 2003; **10**(Suppl 1): 67.
14. Silva MA, Jambulingam PS, Gunson BK, *et al.* Hepatic artery thrombosis following orthotopic liver transplantation: a 10-year experience from a single centre in the United Kingdom. *Liver Transpl* 2006; **12**: 146.
15. Settmacher U, Stange B, Haase R, *et al.* Arterial complications after liver transplantation. *Transpl Int* 2000; **13**: 372.
16. Del Gaudio M, Grazi GL, Ercolani G, *et al.* Outcome of hepatic artery reconstruction in liver transplantation with an iliac arterial interposition graft. *Clin Transplant* 2005; **19**: 399.
17. Vivarelli M, Cucchetti A, La Barba G, *et al.* Ischemic arterial complications after liver transplantation in the adult: multivariate analysis of risk factors. *Arch Surg* 2004; **139**: 1069.
18. Malagó M, Testa G, Frilling A, *et al.* Right living donor liver transplantation: an option for adult patients: single institution experience with 74 patients. *Ann Surg* 2003; **238**: 853.
19. Goss JA, Yersiz H, Shackleton CR, *et al.* In situ splitting of the cadaveric liver for transplantation. *Transplantation* 1997; **64**: 871.
20. Mas VR, Fisher RA, Maluf DG, Wilkinson DS, Garrett CT, Ferreira-Gonzalez A. Hepatic artery thrombosis after liver transplantation and genetic factors: prothrombin G20210A polymorphism. *Transplantation* 2003; **76**: 247.
21. Uzochukwu LN, Bluth EI, Smetherman DH, *et al.* Early postoperative hepatic sonography as a predictor of vascular and biliary complications in adult orthotopic liver transplant patients. *AJR Am J Roentgenol* 2005; **185**: 1558.
22. Maceneaney PM, Malone DE, Skehan SJ, *et al.* The role of hepatic arterial Doppler ultrasound after liver transplantation: an 'audit cycle' evaluation. *Clin Radiol* 2000; **55**: 517.
23. Kok T, Slooff MJ, Thijn CJ, *et al.* Routine Doppler ultrasound for the detection of clinically unsuspected vascular complications in the early postoperative phase after orthotopic liver transplantation. *Transpl Int* 1998; **11**: 272.
24. Nishida S, Kato T, Levi D, *et al.* Effect of protocol Doppler ultrasonography and urgent revascularization on early hepatic artery thrombosis after pediatric liver transplantation. *Arch Surg* 2002; **137**: 1279.
25. Koff RS. Postoperative care: immediate. In: Maddrey WC, Sorrell MF, eds. *Transplantation of the Liver*, Vol. 19. New York, NY: Appleton Lange, 1995: 180–188.