*HPB*, 2006; 8: 29–34

Taylor & Francis
Taylor & Francis Group

**ORIGINAL ARTICLES**

# Liver transplantation for acute hepatic failure

ERIC T. CASTALDO & RAVI S. CHARI

*Division of Hepatobiliary Surgery and Liver Transplantation, Department of Surgery, Vanderbilt University Medical Center, Nashville, USA*

**Abstract**
There are numerous causes of acute hepatic failure (AHF). Cerebral edema, coagulopathy, renal failure, metabolic disturbances and infection are the main clinical sequelae. Patients with AHF should be stabilized when first encountered and transferred to the nearest liver transplant center, as AHF progresses quickly and is often fatal. There are few adequate medical interventions and care of patients with AHF is supportive until spontaneous recovery ensues. If recovery does not appear to occur, most causes of AHF are well accepted indications for liver transplantation.

**Key Words:** *Fulminant hepatic failure, liver transplantation, acute liver failure*

## Introduction

Acute hepatic failure (AHF) has many causes (Table I). It has classically been known as fulminant hepatic failure and was defined in 1970 as occurring in patients with no prior liver disease in which rapid onset of hepatocellular dysfunction ensues with associated encephalopathy within 8 weeks of initial presentation [1]. In 1993, O'Grady et al. [2] redefined the term AHF as the clinical syndrome where encephalopathy occurs between 8 and 28 days after the onset of jaundice. Patients with AHF should be evaluated and stabilized when first encountered. Transfer to the nearest center with liver transplant capabilities should then occur rapidly, as AHF progresses quickly and is often fatal. There are few adequate medical interventions and care of patients with AHF is supportive until spontaneous recovery ensues. If recovery does not appear to occur, most causes of AHF are well accepted indications for liver transplantation [3].

## Etiology of AHF

### *Drug-induced AHF*

Drug-induced AHF is the most common cause of AHF in the United States, and accounts for 15% of all transplants. It is also the most common cause of AHF in the UK. Acetaminophen (APAP) overdose, whether intentional or accidental, is the most common agent causing AHF.

Russo et al. [4] examined the United Network for Organ Sharing (UNOS) liver transplant database from 1990 to 2002 and found that APAP overdose accounted for 46% of patients who underwent liver transplant for drug-induced AHF. APAP combined with another drug accounted for 3% of transplants and nonAPAP drugs alone or in combination accounted for the remaining 51% of liver transplants for AHF.

After APAP, the next most common drugs in descending order of frequency are as follows: isoniazid, propylthiouracil, phenytoin, and valproate [3]. Other less frequent causes of AHF are toxic mushrooms containing amatoxins [5], disulfiram [6], herbal remedies [7], iron toxicity [8], and various other drugs.

### *Virus-induced AHF*

Acute viral hepatitis causing AHF is most commonly caused by hepatitis A or hepatitis B viruses. Hepatitis A and B are still the most common cause of AHF in Japan and France and the second leading cause of AHF in India behind hepatitis E [9]. Schiødt et al. [10] demonstrated that viral hepatitis in the United

Correspondence: Ravi S. Chari, MD, Division of Hepatobiliary Surgery and Liver Transplantation, Suite 801, Oxford House, 1313 21st Avenue South, Vanderbilt University Medical Center, Nashville, TN 37232-4753, USA. Tel: +1 615 936 2573. Fax: +1 615 936 0435. E-mail: ravi.chari@vanderbilt.edu

ISSN 1365-182X print/ISSN 1477-2574 online 
DOI: 10.1080/13651820500465741

Table I. Causes of acute hepatic failure.

| Drug-induced | Viral causes | Other causes |
|---|---|---|
| Acetaminophen (APAP) | Hepatitis A, B, C, E | Acute fatty liver of pregnancy |
| Isoniazid | Cytomegalovirus | Lymphoma |
| Propylthiouracil | Epstein–Barr virus | Ischemic hepatitis |
| Phenytoin | Herpes simplex virus | Acute Budd-Chiari syndrome |
| Valproate | | Acute Wilson disease |
| | | Autoimmune disease |
| | | Peripartum cardiomyopathy |

States is no longer the major cause of AHF. In addition, they demonstrated that hepatitis A patients had a significantly higher spontaneous recovery and a lower liver transplantation rate when compared with AHF due to hepatitis B. Hepatitis C causing ALF is rare in the United States and Europe, but numerous reports have come from Japan [11]. Other less common causes of virus-induced AHF are hepatitis E [12] (except in India), cytomegalovirus [13], herpes simplex virus [14], and Epstein–Barr virus [15].

*Other causes*

Other less common causes of AHF are acute fatty liver of pregnancy [16], lymphoma [17], ischemic hepatitis [18], acute Budd-Chiari syndrome [19], and acute Wilson disease [20]. In addition, autoimmune disease [21] and peripartum cardiomyopathy [22] have been described as causes of AHF.

## Manifestations of acute hepatic failure

*Encephalopathy and cerebral edema*

The most lethal complication associated with acute liver failure is the development of encephalopathy and cerebral edema, which can lead to uncal herniation and death. In patients with chronic hepatic failure, the standard of care is lactulose therapy and bacterial decontamination of the gastrointestinal tract with neomycin. These therapies are not effective in AHF [23]. The encephalopathy of AHF is progressive and life-threatening. It begins with euphoria, anxiety, asterixis or flapping tremor, and can progress to lethargy, somnolence, coma, and death. Electroencephalogram findings are also progressive in nature and range from suppressed alpha rhythms and more prevalent beta rhythms to diffuse bilateral hemispheric asynchronous delta and theta waves with severely disorganized activity [24]. Patients with AHF should have their encephalopathy graded using the West Haven grading system [25] as shown in Table II. In patients whose encephalopathy does not progress past grades 1 or 2, prognosis is excellent. The prognosis for spontaneous liver recovery in patients with grades 3 and 4 is 40% and 20%, respectively [26]. In addition, hepatic encephalopathy of grades 3 or 4 should undergo transfer to an intensive care setting and endotracheal intubation for airway protection. As cerebral edema evolves, treatment should focus on the preservation of cerebral perfusion to prevent ischemia. The intracerebral pressure (ICP) should be measured directly [27]. Cerebral perfusion pressure (CPP) defined as systemic blood pressure minus ICP must be maintained above 40 mm Hg. The mainstay of therapy for treatment of elevated ICP comprises sedation, hypertonic saline, and mannitol [28]. Finally, hypothermia is a modality that has recently been explored that has been shown to lower ICP in those with intracranial hypertension and to prevent the development of intracranial hypertension in those with encephalopathy who have yet to develop it [29].

*Coagulopathy*

An important manifestation of AHF is coagulopathy. This is typically measured using prothrombin time (PT) or international normalized ratio (INR). Coagulopathy occurs due to decreased synthesis of clotting factors, an increase in peripheral consumption, and at least some degree of disseminated intravascular coagulation and thrombocytopenia [30]. Severe coagulopathy can lead to spontaneous hemorrhage, especially from the gastrointestinal tract. Prophylactic treatment with fresh frozen plasma (FFP) in the

Table II. West Haven criteria for grading mental state in hepatic encephalopathy.

| Grade | Features |
|---|---|
| Grade 0 | No signs or symptoms |
| Grade 1 | Euphoria, anxiety, trivial lack of awareness, impaired performance, shortened attention span, mild asterixis |
| Grade 2 | Lethargy, minimal personality changes, subtle personality change, inappropriate behavior, asterixis |
| Grade 3 | Somnolence, confusion, gross disorientation |
| Grade 4 | Coma |

absence of bleeding is unadvised for two reasons. First, the administration of FFP will lower the PT and will thus decrease the accuracy with which prognosis can be judged. In addition, this can present as a significant volume challenge, thus exacerbating those who may be in renal failure and contributing to increases in ICP [31]. Patients with AHF should be placed on $H_2$ receptor antagonists and/or proton pump inhibitors to reduce the risk of spontaneous hemorrhage from the upper gastrointestinal tract.

Plasmapheresis can also play a role in patients with AHF and life-threatening bleeds. Although plasmapheresis will not help the liver regenerate or impact the neurologic complications of AHF, it can help to maintain a more normal coagulation profile and lessen the chance of life-threatening hemorrhage [32].

### *Renal failure*

Renal failure is another manifestation of AHF that is multifactorial in nature. Some drugs when taken in excess, such as APAP, cause injury to nephrons and result in renal failure in addition to AHF. Volume depletion and systemic hypoperfusion can cause acute tubular necrosis and renal failure or exacerbate existing renal failure. The hepatorenal syndrome is another cause of acute renal failure. It is characterized by intense constriction of renal cortical vasculature with resulting oliguria and sodium retention. It is defined as functional renal failure in the setting of cirrhosis in histologically normal kidneys [33]. Finally, sepsis and a decrease in peripheral vascular resistance can also either cause or exacerbate renal failure. Many patients will go on to require hemodialysis as a result of renal failure. Continuous hemodialysis is preferred to intermittent, so as to avoid large variations in volume status and increases in CPP.

### *Infection*

Patients with AHF are functionally immunosuppressed and bacterial or fungal infection is common and can be detrimental. In addition, most patients with AHF will require central venous access and mechanical ventilation, which also increase the risk of infection. Infections have been temporally associated with a worsening encephalopathy, especially in APAP overdose [34]. Approximately 60% of patients with AHF will become infected and many of these will develop a systemic inflammatory response syndrome (SIRS). The mortality rate for patients who go on to develop severe sepsis or septic shock is 59% and 98%, respectively [35]. The utility of prophylactic antibiotics in AHF has not been established. Furthermore, detecting an infection can be quite difficult due to manifestations of numerous metabolic disturbances induced by AHF. Serial blood cultures for bacteria and fungi are appropriate for detecting infections. A high index of suspicion must be maintained and antibiotics should be administered with a low threshold when it is felt to be appropriate.

### *Metabolic disturbances*

Numerous metabolic disturbances accumulate during AHF. Hypoglycemia occurs due to increasing levels of insulin, an inability to mobilize glycogen stores, and impaired gluconeogenesis. Hypoglycemia responds to intravenous administration of glucose. Metabolic acidosis can occur. This is multifactorial and depends on the mechanism of hepatic injury. Typically, it is a metabolic acidosis and results from the direct effects of hepatotoxic drugs such as APAP. In addition, this can be the manifestation of global hypoperfusion and lactic acidosis due to volume depletion [36]. Several other manifestations such as hypophosphatemia, hyponatremia, and alkalosis can occur.

### *Cardiovascular*

The cardiovascular manifestations of AHF are similar to systemic sepsis. They are characterized by vasodilatation with a compensatory increase in cardiac output. These effects are thought to be mediated by circulating endotoxin and tumor necrosis factor. Hypovolemia compounds the effects of AHF. Pulmonary artery catheters are warranted to assess the adequacy of filling pressures as well as other hemodynamic parameters. If hypotension ensues, prognosis worsens. Hypotension leads to lower CPP and deepening encephalopathy with rising ICP. Treatment goals are to restore the circulating volume and supportive care with vasopressors.

Arrhythmias are another manifestation of AHF. Arrhythmias typically result from a definable source such as electrolyte imbalance. Therapy is directed at the underlying cause of the arrhythmia.

## Prognostic factors

Initial efforts in the treatment of AHF are aimed at delineating the underlying cause. Ostapowicz et al. [37] studied 308 patients prospectively over a 41-month period and determined that patients with AHF from APAP overdose, hepatitis A, ischemic hepatitis, or pregnancy-related acute liver failure had a short-term survival (3 weeks) without transplantation of $\geq 50\%$. Patients whose AHF was from indeterminate causes, nonAPAP drug overdose, hepatitis B virus, autoimmune hepatitis, Wilson disease, or Budd-Chiari syndrome had lower rates of short-term transplant-free survival ($<25\%$).

Symptom duration has also been used to assess prognosis. Patients with nonAPAP-related liver failure can be stratified into three subsets: hyperacute, acute, and subacute liver failure [2]. Hyperacute liver failure is the onset of hepatic encephalopathy within 7 days of symptoms. Acute failure is 8–28 days of symptoms

before onset of encephalopathy. Finally, subacute failure is the onset of hepatic encephalopathy after 28 days of symptoms. Short-term, transplant-free survival is worse in patients with the subacute group of AHF (14%) than patients in the hyperacute (30%) or acute (33%) groups [30].

Several other variables have been used to identify their effect on survival. Body mass index, age, serum bilirubin, and serum creatinine seem to be the most important [38,39]. Children with AHF rarely develop hepatic encephalopathy and if it occurs, it is an ominous sign. Therefore, different factors play a role. The main prognostic factor is PT or INR. A PT prolonged beyond 90 s or an INR >4 are associated with a mortality that exceeds 90% [40].

## Liver support systems

There have been attempts at artifical liver replacement in the setting of AHF. In general, there are two types of artifical liver replacement, cell-based therapies and dialysis-based therapies or plasmapheresis.

Liver support systems that do not use biologic tissue include extracorporeal albumin dialysis (ECAD), molecular absorbent recycling systems (MARS), and plasmapheresis. Although there has been anecdotal support for these techniques, data in support of these techniques in AHF are scant [41].

Two liver support systems that do use biologic means to support patients in AHF have also been evaluated in the past 10 years. One incorporated porcine hepatocytes, the other a hepatoblastoma cell line. Unfortunately, these have also failed to show a proven benefit against supportive care alone [9].

To date, 11 different devices have been reported in clinical application and 3 of these have been studied in randomized controlled clinical trials, none of which have shown a survival benefit [42]. In general, artifical support systems have failed to show significant survival benefit in controlled trials and have been used as a 'bridge' to transplantation in patients with AHF. Sekido et al. [43] have reported improvements in pulmonary and circulatory profiles among pre-transplant patients before receiving a live donor hepatic graft.

## Selection criteria for transplantation

UNOS has developed a special status 1 category for patients with AHF. The definition of status 1 for adults includes those with AHF and encephalopathy who are in an intensive care unit with a life expectancy of <7 days without a liver transplant. In children under 18 years of age, status 1 includes those in an intensive care unit with acute or chronic liver disease who have experienced one of the following: gastrointestinal bleeding, hepatorenal syndrome, refractory ascites, uncontrolled portosystemic encephalopathy, and an estimated life expectancy of <7 days. Status 1 also includes patients with primary graft failure, hepatic artery thrombosis <7 days post transplant, or fulminant Wilson disease.

There are several factors that are important in the prognosis of patients with AHF. Several predictive models have been developed to determine when liver transplantation is indicated. The most widely accepted criteria are the King's College criteria (Table III). The model for end-stage liver disease (MELD) and the pediatric end-stage liver disease (PELD) systems are detailed in Table IV. While the MELD/PELD was developed to predict mortality in patients with chronic liver disease, it has recently been compared to the King's College criteria. The MELD/PELD appears to be an excellent predictor of outcome in both adults and children with AHF. In addition, there appear to be a lower false negative rate with MELD/PELD, which would predict fewer transplants for patients who would have spontaneously recovered [44].

## Results of transplantation for AHF

Approximately 5% of patients who are on the UNOS waiting list have AHF and are listed as status 1. From 1994 to 2003, 49% of these patients received liver transplantation within 15 days of being listed [45]. Patients with AHF who received transplant had a 1-year survival rate of 81% during this same time period. In addition, this same group of patients had a graft survival of 83% at 3 months and 75% at 1 year post transplant. Furthermore, 18% of status 1 patients died during this same time period awaiting

Table III. King's College criteria for liver transplantation in AHF.

| APAP-associated AHF | All other causes of AHF |
|---|---|
| pH <7.3<br>or<br>INR >6.5, serum creatinine >3.4 mg/dl, and grade III–IV encephalopathy | INR >6.5<br>or<br>Three of the following variables:<br>1. Age <10 or >40 years<br>2. Cause is nonA, nonB hepatitis or idiosyncratic drug reaction<br>3. Duration of jaundice before encephalopathy >7 days<br>4. INR >3.5<br>5. Serum bilirubin >17.5 mg/dl |

APAP, acetaminophen; INR, international normalized ratio.

Table IV. MELD/PELD characteristics used in calculating scores to determine prognosis.

| MELD | PELD |
|---|---|
| Serum creatinine (mg/dl)* | Albumin (g/dl) |
| Bilirubin (mg/dl) | Bilirubin (mg/dl) |
| INR | INR |
| *Patients who have had dialysis twice in the past week are automatically set to a creatinine of 4 mg/dl | Growth failure (based on gender, height, and weight) |
| | Age at listing |

INR, international normalized ratio.

transplantation. Meanwhile, 88% of patients undergoing transplantation for reasons other than AHF survived for 1 year. These results are similar to those found in Europe. According to the European Liver Transplant Registry (ELTR), in a 13-year period ending in 2001, the ELTR had a 1-year graft survival of 60% and a 1-year patient survival of 65% for all forms of AHF [46]. Other small studies have also determined that there is a worse post transplant patient survival after liver transplantation on an urgent basis [47]. In addition, it should be noted that as the stage of encephalopathy progresses (I to IV), patient survival subsequently worsens [2].

These results have led to the sharing of organs for status 1 patients within specific regions in the United States. Sharing of organs within regions has led to shorter waiting times and improved post transplant survival, with a subsequent decrease in waiting list mortality and postoperative complications [48].

Due to the shortage of suitable organs for transplantation and the high mortality associated with AHF, some have suggested living donation for patients with AHF. In Asia, living donors for patients with AHF have been used as a proactive way to increase the organ pool with success and this has been shown to be a viable option [49,50].

## References


[1] Trey C, Davidson C. The management of fulminant hepatic failure. Prog Liver Dis 1970;3:292.

[2] O'Grady JG, Schalm SW, Williams R. Acute liver failure: redefining the syndromes. Lancet 1993;342:273–5.

[3] Van Thiel DH, Nadir A, Shah N. Liver transplantation: who and when? Transplant Proc 2002;34:2465–7.

[4] Russo MW, Galanko JA, Shrestha R, Fried MW, Watkins P. Liver transplantation for acute liver failure from drug induced liver injury in the United States. Liver Transplant 2004;10: 1018–23.

[5] Ganzert M, Felgenhauer N, Zilker T. Indication of liver transplantation following amatoxin intoxication. J Hepatol 2005;42:202–9.

[6] Meier M, Woywodt A, Hoeper MM, Schneider A, Manns MP, Strassburg CP. Acute liver failure: a message found under the skin. Postgrad Med J 2005;81:269–70.

[7] Skoulidis F, Alexander GJM, Davies SE. Ma huang associated acute liver failure requiring liver transplantation. Eur J Gastroenterol Hepatol 2005;17:581–4.

[8] Daram SR, Hayashi PH. Acute liver failure due to iron overdose in an adult. South Med J 2005;98:241–4.

[9] O'Grady JG. Acute liver failure. Postgrad Med J 2005;81: 148–54.

[10] Schiødt FV, Davern TJ, Shakil AO, McGuire B, Samuel G, Lee WM. Viral hepatitis-related acute liver failure. Am J Gastroenterol 2003;98:448–53.

[11] Chu CM, Sheen IS, Liaw YF. The role of hepatitis C virus in fulminant viral hepatitis in an area with endemic hepatitis A and B. Gastroenterology 1994;107:189–95.

[12] Khuroo MS, Kamili S. Aetiology and prognostic factors in acute liver failure in India. J Viral Hepatitis 2003;10:224–31.

[13] Willams R, Riordan SM. Acute liver failure: established and putative hepatitis viruses and therapeutic implications. J Gastroenterol Hepatol 2000;15S:G17–25.

[14] Boysen T, Clausen MR. A case of acute liver failure caused by herpes simplex virus type 2. Scand J Infect Dis 2004;36:529–32.

[15] Palanduz A, Yaldirmak Y, Telhan A, Arapoglu M, Urganci N, Tufekci S, et al. Fulminant hepatic failure and autoimmune hemolytic anemia associated with Epstein-Barr virus infection. J Infect 2002;45:96–8.

[16] Steingrub JS. Pregnancy-associated severe liver dysfunction. Crit Care Clin 2004;20:763–6.

[17] Lettieri CJ, Berg BW. Clinical features of non-Hodgkin's lymphoma with acute liver failure: a report of five cases and review of published experience. Am J Gastroenterol 2003;98: 1641–6.

[18] Giallourakis CC, Rosenberg PM, Friedman LS. The liver in heart failure. Clin Liver Dis 2002;6:947–67.

[19] Bogin V, Marcos A, Shaw-Stiffel T. Budd-Chiari syndrome: in evolution. Eur J Gastroenterol Hepatol 2005;17:33–5.

[20] Brewer GJ, Askari FK. Wilson's disease: clinical management and therapy. J Hepatol 2005;42(S1):14–21.

[21] Kessler WR, Cummings OW, Eckert G, Chalasani N, Lumeng L, Kwo PY. Fulminant hepatic failure as the initial presentation of acute autoimmune hepatitis. Clin Gastroenterol Hepatol 2004;2:625–31.

[22] Fussell KM, Awad JA, Ware LB. Case of fulminant hepatic failure due to unrecognized peripartum cardiomyopathy. Crit Care Med 2005;33:891–3.

[23] Biel AT, Córdoba J. Practice parameters committee of the American College of Gastroenterology. Hepatic encephalopathy. Am J Gastroenterol 2001;96:1968–76.

[24] Amodio P, Marchetti P, Del Piccolo F, de Tourtchainoff M, Varghese P, Zuliani C, et al. Spectral versus EEG analysis in mild hepatic encephalopathy. Clin Neurophysiol 1999;110: 1334–44.

[25] Ong JP, Aggarwal A, Krieger D, Easley KA, Karafa MT, Van Lentz F, et al. Correlation between ammonia levels and the severity of hepatic encephalopathy. Am J Med 2003;114:188–93.

[26] Hoofnagle JH, Carithers RL Jr, Shapiro C, Ascher N. Fulminant hepatic failure: summary of a workshop. Hepatology 1995;21:240–52.

[27] Punch JD. Bridges to transplantation. Anesthesiol Clin North Am 2004;22:863–9.

[28] Tofteng F, Larsen FS. Management of patients with fulminant hepatic failure and brain edema. Metab Brain Dis 2004;19: 207–14.

[29] Jalan R, Rose C. Hypothermia in acute liver failure. Metab Brain Dis 2004;19:215–21.

[30] O'Grady JG, Langley PG, Isola LM, Aledort LM, Williams R.. Coagulopathy of fulminant hepatic failure. Semin Liver Dis 1986;6:159–63.

[31] Yee HF Jr, Lidofsky SK. Acute liver failure. In: Feldman M, Friedman LS, Sleisenger MH, editors. Sleisenger & Fordtran's gastrointestinal and liver disease. Philadelphia, PA: Elsevier; 2002:1567–76.

[32] Singer AL, Olthoff KM, Kim H, Rand E, Zamir G, Shaked A. Role of plasmapheresis in the management of acute hepatic failure in children. Ann Surg 2001;234:418–24.

[33] Fitz JG. Hepatic encephalopathy, hepatopulmonary syndromes, hepatorenal syndrome, coagulopathy, and endocrine complications of liver disease. In: Feldman M, Friedman LS, Sleisenger MH, editors. Sleisenger & Fordtran's gastrointestinal and liver disease. Philadelphia, PA: Elsevier; 2002:1567–76.

[34] Vaquero J, Polson J, Chung C, Helenowski I, Schiodt FV, Reisch J, et al. Infection and the progression of hepatic encephalopathy in acute liver failure. Gastroenterology 2003; 125:755–64.

[35] Rolando N, Wade J, Davalos M, Wendon J, Philpott-Howard J, Williams R. The systemic inflammatory response syndrome in acute liver failure. Hepatology 2000;32:734–9.

[36] O'Grady JG, Alexander FH, Hayllar KM, Williams R. Early indicators of prognosis in fulminant hepatic failure. Gastroenterology 1989;97:439–45.

[37] Ostapowicz G, Fontana RJ, Schiødt FV, Larson A, Davern TJ, Han SH, et al. Results of a prospective study of acute liver failure at 17 tertiary care centers in the United States. Ann Intern Med 2002;137:947–55.

[38] Thuluvath PJ, Yoo HY, Thompson RE. A model to predict survival at one month, one year, and five years after liver transplantation based on pretransplant clinical characteristics. Liver Transplant 2003;9:527–32.

[39] Wigg AJ, Gunson BK, Mutimer DJ. Outcomes following liver transplantation for seronegative acute liver failure: experience during a 12-year period with more than 100 patients. Liver Transplant 2005;11:27–34.

[40] Baker A, Dhawan A, Heaton N. Who needs a liver transplant? (new disease specific indications). Arch Dis Child 1998;79: 460–4.

[41] Mullen KD, Dasarathy S.. MARS – does it stand the test of time? Metab Brain Dis 2004;19:223–8.

[42] Van de Kerkhove MP, Hoekstra R, Chamuleau RAFM, van Gulik TM. Clinical application of bioartificial liver support systems. Ann Surg 2004;240:216–30.

[43] Sekido H, Matsuo K, Takeda K, Ueda M, Morioka D, Kubota T, et al. Usefulness of artificial liver support for pretransplant patients with fulminant hepatic failure. Transplant Proc 2004; 36:2355–6.

[44] Wiesner RH. MELD/PELD and the allocation of deceased donor livers for status 1 recipients with acute fulminant hepatic failure, primary nonfunction, hepatic artery thrombosis, and acute Wilson's disease. Liver Transplant 2004; 10(Suppl 2):S17–22.

[45] Hanto DW, Fishbein TM, Pinson CW, Olthoff KM, Shiffman ML, Punch JD, et al. Liver and intestine transplantation: summary analysis, 1994–2003. Am J Transplant 2005;5:916–33.

[46] Adam R, McMaster P, O'Grady JG, Castaing D, Klempnauer JL, Jamieson N, et al. Evolution of liver transplantation in Europe: report of the European liver transplant registry. Liver Transplant 2003;9:1231–43.

[47] Zieniewicz K, Skwarek A, Nyckowski P, Pawlak J, Michalowicz B, Patkowski W, et al. Comparison of the results of liver transplantation for elective versus urgent indications. Transplant Proc 2003;35:2262–4.

[48] Humar A, Khwaja K, Glessing B, Larson E, Asolati M, Durand B, et al. Regionwide sharing for status 1 liver patients – beneficial impact on waiting time and pre- and posttransplant survival. Liver Transplant 2004;10:661–5.

[49] Wu YM, Ho MC, Hu RH, Ko WJ, Yang PM, Lai MY, et al. Liver transplantation for acute liver failure. Transplant Proc 2004;36:2226–7.

[50] Liu CL, Fan ST, Lo CM, Yong BH, Fung AS, Wong J. Right-lobe live donor liver transplantation improves survival of patients with acute liver failure. Br J Surg 2002;89:317–22.