**Name of journal:** ***World Journal of Gastroenterology***

**ESPS Manuscript NO: 21101**

**Manuscript Type: ORIGINAL ARTICLE**

***Retrospective Cohort Study***

**Predictive factors for survival and score application in liver retransplantation for hepatitis C recurrence**

Song ATW *et al*. Retransplantation in HCV recurrence

Alice Tung Wan Song, Rodolphe Sobesky, Carmen Vinaixa, Jérôme Dumortier, Sylvie Radenne, François Durand, Yvon Calmus, Géraldine Rousseau, Marianne Latournerie, Cyrille Feray, Valérie Delvart, Bruno Roche, Stéphanie Haim-Boukobza, Anne-Marie Roque-Afonso, Denis Castaing, Edson Abdala, Luiz Augusto Carneiro D’Albuquerque, Jean-Charles Duclos-Vallée, Marina Berenguer, Didier Samuel

**Alice Tung Wan Song, Rodolphe Sobesky, Bruno Roche, Denis Castaing, Jean-Charles Duclos-Vallée, Didier Samuel,** INSERM Unit 785, Villejuif 94800, France

**Alice Tung Wan Song, Edson Abdala, Luiz Augusto Carneiro D’Albuquerque**, Liver and Digestive Organ Transplantation Division, Hospital Clinicas, São Paulo 05403-900, Brazil

**Alice Tung Wan Song, Rodolphe Sobesky, Bruno Roche, Denis Castaing, Jean-Charles Duclos-Vallée,** Didier Samuel*,* Université Paris-Sud, Villejuif 94800, France

**Alice Tung Wan Song, Luiz Augusto Carneiro D’Albuquerque,**Liver Transplantation Laboratory LIM-37, São Paulo 01246-903, Brazil

**Alice Tung Wan Song, Rodolphe Sobesky, Valérie Delvart, Bruno Roche, Stéphanie Haim-Boukobza, Anne-Marie Roque-Afonso, Denis Castaing, Jean-Charles Duclos-Vallée, Didier Samuel,** AP-HP Hôpital Paul Brousse, Villejuif 94800, France

**Carmen Vinaixa, Marina Berenguer,** La Fe Hospital, University of Valencia & Ciberehd, Valencia 46026, Spain

**Jérôme Dumortier**, Hôpital Edouard Herriot, Lyon 69003, France

**Sylvie Radenne,** Hôpital Croix Rousse, Lyon 69004, France

**François Durand,** AP-HP Hôpital Beaujon, Clichy 92110, France

**Yvon Calmus,** AP-HP Hôpital St Antoine, Paris 75011, France

**Géraldine Rousseau,** AP-HP Hôpital Salpétrière, Paris 75013, France

**Marianne Latournerie,** CHU Pontchaillou, Rennes 35000, France

**Cyrille Feray**, AP-HP Hôpital Henri Mondor, Creteil 94010, France

**Edson Abdala,** Viral Hepatitis Laboratory LIM-47, São Paulo 01246-903, Brazil

**Author contributions:** Song ATW, Sobesky R, Castaing D, Abdala E, D’Albuquerque LAC, Duclos-Vallée JC, Berenguer M and Samuel D participated in research design; Song ATW, Sobesky R, Vinaixa C, Dumortier J, Radenne S, Durand F, Calmus Y, Rousseau G, Latournerie M, Feray C, Roche B, Haim-Boukobza S and Roque-Afonso AM participated in data collection; Song ATW and Delvart V participated in data analysis; Song ATW, Sobesky R, Vinaixa C, Abdala E, Berenguer M and Samuel D participated in writing the paper; all authors drafted the article and approved the final version of the submitted article.

**Supported by** a research grant from São Paulo Research Foundation (FAPESP grant number 2012/03895-6).

**Institutional review board statement:** The institutional review board of the Centre Hépato-Biliaire (Hôpital Paul Brousse) approved the study and written consent was obtained from all patients. Access to medical charts was in agreement with French ethical laws.

**Informed consent statement:** All study participants provided informed consent prior to study enrollment.

**Conflict-of-interest statement:** The authors did not receive any commercial financial support that could create conflicts of interest to this paper.

**Data sharing statement:** Technical appendix, statistical code, and dataset available from the corresponding author at [alicetwsong@gmail.com](mailto:alicetwsong@gmail.com). In all centres, participants gave informed consent for data sharing before transplantation.

**Open-Access:** This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

**Correspondence to: Alice Tung Wan Song, MD, PhD,** Liver and Digestive Organ Transplantation Division, Gastroenterology Department, University of São Paulo Medical School, São Paulo 05403-900, Brazil. alicetwsong@gmail.com

**Telephone:** +55-11-26613323

**Fax:** +55-11-26613323

**Received:** June 29, 2015

**Peer-review started:** July 3, 2015

**First decision:** September 29, 2015

**Revised:** November 26, 2015

**Accepted:** January 17, 2016

**Article in press:**

**Published online:**

**Abstract**

**AIM:** To identify risk factors associated with survival in patients retransplanted for hepatitis C virus (HCV) recurrence, and to apply a survival score to this population.

**METHODS:** We retrospectively identified 108 patients retransplanted for HCV recurrence in eight European liver transplantation centres (seven in France, one in Spain). Data collection included clinical and laboratory variables, including virological and antiviral treatment data. We then analysed the factors associated with survival in this population. A recently published score that predicts survival in retransplantation in patients with hepatitis C was applied. Because there are currently no uniform recommendations regarding selection of the best candidates for retransplantation in this setting, we also described the clinical characteristics of 164 patients not retransplanted, with F3, F4 or fibrosing cholestatic hepatitis (FCH) post-first graft presenting with hepatic decompensation.

**RESULTS:** Overall retransplantation patient survival rates were 55%, 47% and 43% at 3, 5, and 10 years, respectively. Patients who were retransplanted for advanced cirrhosis had survival rates of 59%, 52%, and 49% at 3, 5, and 10 years, while those retransplanted for FCH had survival rates of 34%, 29%, and 11%, respectively. Under multivariate analysis, and adjusting for the centre effect and the occurrence of FCH, factors associated with better survival after retransplantation were: negative HCV viremia before retransplantation, antiviral therapy after retransplantation, non-genotype 1, a Model for End-stage Liver Disease (MELD) score < 25 when replaced on the waiting list, and a retransplantation donor age < 60 years. Although the numbers were small, in the context of the new antivirals era, we also showed that outcomes in patients who underwent retransplantation with undetectable HCV viremia did not depend on donor age and MELD score. The Andrés score was applied to 102 patients for whom all score variables were available, and this produced a mean score of 43.4 (SD = 6.6). Survival rates after the date of the first decompensation post-LT1 in the liver retransplantation (reLT) group (94 patients decompensated) at 3, 5, and 10 years, were 62%, 59%, and 51%, respectively among 78 retransplanted individuals with advanced cirrhosis, and 42%, 32%, and 16%, among 16 retransplanted individuals with FCH. In the non-reLT group with hepatic decompensation, survival rates were 27%, 18%, and 9% at 3, 5, and 10 years, respectively (*p* < 0.0001). Compared with non-retransplanted patients, retransplanted patients were younger at LT1 (mean age 48 ± 8 years compared to 53 ± 9 years in the no reLT group, *p* < 0.0001), were less likely to have HIV co-infection (4% *vs* 14% among no reLT patients, *p* = 0.005), more likely to have received corticosteroid bolus therapy after LT1 (25% in reLT *vs* 12% in the no reLT group, *p* = 0.01), and to have presented with SVR after the first transplantation (20% in the reLT group *vs* 7% in the no reLT group, *p* = 0.028).

**CONCLUSION:** antiviral therapy before and after retransplantation had a substantial impact on survival in the context of retransplantation for HCV recurrence, and with the new direct-acting antivirals now available, outcomes should be even better in the future.

**Key words:** antivirals; hepatitis C; mortality; prognosis; retransplantation; risk factors

**© The Author(s) 2016.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Core tip:** Liver retransplantation for hepatitis C recurrence may be a subject of debate. This study was carried out in order to assist patient selection for retransplantation in a context of donor scarcity. It was a retrospective multicentre study that analyzed predictive factors for survival in a population of patients retransplanted for hepatitis C virus recurrence, including virological and antiviral treatment data. We also applied a previously published score to this population.

Song ATW, Sobesky R, Vinaixa C, Dumortier J, Radenne S, Durand F, Calmus Y, Rousseau G, Latournerie M, Feray C, Delvart V, Roche B, Haim-Boukobza S, and Roque-Afonso AM, Castaing D, Abdala E, D’Albuquerque LAC, Duclos-Vallée JC, Berenguer M, and Samuel D. Predictive factors of survival and score application in liver retransplantation for hepatitis C recurrence.*World J Gastroenterol* 2016; In press

**INTRODUCTION**

Advanced liver disease caused by hepatitis C virus (HCV) is the leading cause of liver transplantation (LT) in Western countries[1,2]. The post-transplant detection of HCV ribonucleic acid (RNA) in the serum or graft is universal in pre-LT viremic patients[3,4]. Histologically documented chronic hepatitis C develops in approximately 70% of patients during the first year after LT[5]. Progression of this disease is particularly aggressive in transplanted patients, with a rapid evolution towards fibrosis (cirrhosis within approximately 9 to 12 years) when compared to immunocompetent individuals (cirrhosis within approximately 20-30 years)[4], resulting in graft loss due to recurrent disease[6]. A previous study showed that patients with clinically compensated graft cirrhosis achieved a one-year survival rate of 74%, but this rate fell to 41% in those with clinical decompensation[7]. In patients with established cirrhosis and graft failure, retransplantation (reLT) is the only therapeutic option[8]. But because of organ shortages, cost issues and poorer survival, the indications for reLT must be appropriate[9]. In previous studies, HCV-related disease did not indicate a poorer prognosis following reLT[9–21], while other studies identified HCV recurrence as an independent predictive factor of mortality[22–24]. But few studies have evaluated risk factors for mortality among patients retransplanted for HCV recurrence[25–29].

***Predictive models for retransplantation***

In order to predict post-reLT survival and therefore aid in patient selection, several scores have been developed[30,31]. That most widely employed is the Rosen score[32]. However, like many others, this model was based on reLT cases in general, and not just on cases of HCV recurrence.

The first score specifically designed for HCV-positive patients was published recently by Andres *et al*[29]. This paper analysed registry data from the Scientific Registry of Transplant Recipients on 1422 individuals transplanted for HCV and retransplanted at least 30 d after the first transplant. In order to design a score that could predict survival after reLT, they identified six predictive variables associated with survival: recipient age at the time of the first transplant, interval elapsing between the two transplants, donor age, creatinine levels, international normalized ratio (INR), and serum albumin values before the second transplant.

Several factors currently influence the decision to retransplant patients who have experienced a recurrence of HCV after transplantation. These include factors related to the individual patient, the physician's judgement, transplant centre policies and experience, and geographic donor organ availability. There are no uniform guidelines to indicate which patients with HCV recurrence should undergo reLT. A survey in 2003 showed that nearly all transplant centres in the US were likely to offer reLT to patients experiencing an HCV recurrence[33]. The scenario is most likely to change radically with the development of new direct-acting antivirals (DAA). However, these drugs may not be available in some countries in the short- or medium-term.

The present study was performed in order to identify predictive survival factors in patients with HCV-related graft failure undergoing liver reLT before the era of new antivirals, and to apply a previously published score[29] that predicts survival after reLT in recipients with HCV recurrence. Secondary objectives included a description of the natural history of HCV in retransplanted patients compared to their first transplantation, and a description of a group of patients experiencing graft failure due to HCV recurrence who were not retransplanted, in order to clarify which patients were selected for reLT, as there are no uniform criteria for reLT in the setting of HCV recurrence.

**Materials and methods**

***Study design and population***

This was a retrospective and multicentre study involving seven liver transplantation centres in France (Paul Brousse, Edouard Herriot, Beaujon, Saint Antoine, Pitié-Salpétrière, Rennes and Henri Mondor Hospitals), and one centre in Spain (La Fe Hospital). There were no specific recommendations regarding reLT criteria for HCV-related recurrence, and the indication for reLT depended on each centre’s policies. However, all centres generally indicated reLT in patients with graft failure, using the same criteria as those applied for the first transplantation. Protocol biopsies were performed yearly in all French centres, but not in the Spanish centre. Immunosuppression protocols were similar, with the use of cyclosporine or tacrolimus, corticosteroids during the first 6-12 mo, and/or mycophenolate mofetil. Antiviral treatment policies were also similar; treatment was initiated with any degree of fibrosis or fibrosing cholestatic hepatitis, given that the clinical conditions were sufficient to undergo antiviral therapy.

We included patients aged 18 or older who had undergone LT for HCV-related disease and then reLT with HCV recurrence as the main indication between January 1994 and June 2012 (reLT group). HCV recurrence was confirmed histologically as the principal reason for reLT by prior biopsies or an explant displaying cirrhosis or fibrosing cholestatic hepatitis. Patients with hepatitis B (HBV) co-infection with positive HBV DNA after the first LT (LT1) were excluded.

In order to describe which patients were selected for reLT in the absence of uniform criteria for reLT in the setting of HCV recurrence, we also identified those transplanted for HCV-related disease and presenting with graft failure but who were not retransplanted (no reLT group). This group represented the population in whom reLT may have been indicated, as opposed to those with cirrhosis and no clinical decompensation, in whom reLT would not have been indicated. The inclusion criteria were: patients aged 18 or older receiving LT between January 1994 and June 2012 for HCV-related disease and experiencing HCV recurrence in the form of Metavir F3, F4 or fibrosing cholestatic hepatitis (FCH) (confirmed histologically), presenting with clinical hepatic decompensation (defined as the presence of ascites, encephalopathy, variceal haemorrhage or jaundice), who had not undergone reLT, and with positive serum HCV RNA after the first transplantation. Exclusion criteria were patients with HBV co-infection with positive HBV DNA after transplantation.

***Case identification***

Retransplanted patients were identified by consulting prospectively maintained databases in the Spanish centre and in five of the French centres, or the database operated by the French Biomedicine Agency (Agence de la Biomédecine), which covered the two other French centres. This agency is a public organization under the supervision of the French Ministry of Health, whose responsibilities include organising the procurement and transplantation of organs, tissues and cells. All transplant centres in France are required to report all their cases to this agency.

To identify cases of non-retransplanted patients with advanced liver disease/FCH and graft failure in all centres, all patients transplanted for HCV-related disease were identified first of all. After that, all post-LT biopsies revealing F3, F4 or FCH were included, and a chart review was performed in order to identify those presenting with hepatic decompensation (defined as the presence of ascites, encephalopathy, variceal haemorrhage or jaundice).

***Data collection and definitions***

After case identification, data were collected by consulting the prospectively maintained databases when available, which included several variables. Variables not available in the databases were collected through chart review in all centres.

The following data were collected:

**Regarding the first and second transplantations:** Donor age and gender, living or deceased donor, donor HCV serology, recipient age and gender, concomitant kidney transplantation, acute rejection episodes after LT, receipt of corticosteroid bolus, receipt of OKT3, maintenance immunosuppressive regimen, HCV treatment (medication and duration), reason for treatment discontinuation, HCV treatment response (as previously defined[34]), presence of hepatocellular carcinoma (HCC) prior to LT1, presence of alcoholic disease prior to LT1, human immunodeficiency virus (HIV) co-infection, diabetes mellitus pre or post-LT, Metavir fibrosis score on biopsies post-transplant, presence and timing of FCH, HCV viremia levels before LT1 and before reLT, HCV genotype, date and type of hepatic decompensation, biochemical data 20-30 d after decompensation, fibrosis progression rate[35], date and cause of death, reason for no reLT, and patient and graft survival (the latter being defined as the interval between the date of transplant and the date of hepatic decompensation or death).

**Regarding the second transplantation:** MELD (Model for End-stage Liver Disease) score prior to transplant, pre-reLT bilirubin, pre-reLT creatinine, pre-reLT INR, pre-reLT albumin, date and type of decompensation, number of days of ICU hospitalisation prior to reLT, date of graft failure (defined as clinical hepatic decompensation), and date and cause of death.

***Survival score***

The survival score published previously by Andres *et al*[29] was applied to all reLT cases for which such score variables were available. This score was calculated as follows:

(0.23 × donor age) + (4.86 × creatinine log) - (2.45 × interval between the first and second transplant log) + (2.69 × INR) - (0.10 × recipient age) + (3.27 × albumin + 40).

***Statistical analysis***

The primary endpoint was to determine predictive factors for survival after reLT for a recurrence of hepatitis C. Graft and patient survival probabilities were determined using the Kaplan-Meier method and compared using the log-rank test. A Cox model with a likelihood ratio test was used to compare the difference in survival for continuous variables. Variables with a p value below 0.15 under univariate analysis were included in order to enable a stepwise multivariate evaluation using the Cox multivariate model, with the calculation of hazard ratios and corresponding 95% confidence intervals. Under multivariate analysis, a p value of 0.05 or lower was considered to be significant. A predictive model was constructed with the aim of predicting survival in individual patients retransplanted for hepatitis C recurrence according to the presence of prognostic factors[36]. For this, donor age was categorized as more or less than 60 years considering the scarcity of young donors, and MELD score superior or inferior to 25[37]. Data were compared between retransplanted and non-retransplanted patients using the chi-square test for categorical data and the independent samples *t*-test for continuous data. Survival comparisons between the two groups were performed by taking account of the date of the first decompensation, considering that this could be the moment at which re-listing would be discussed. Differences between fibrosis progression rates were calculated using a paired T test. A p value of 0.05 or lower was considered to be significant. Statistical analyses were performed using SAS software version 9.1.3 (SAS Institute Inc., Cary, NC, United States).

**Results**

Between January 1994 and June 2012, 11341 LTs were performed in the eight study centres, and in 2586 (23%) the main indication was HCV-related disease. Of these, 372 (14%) patients progressed to F3 or F4, and 91 patients were retransplanted. Forty-three patients (2%) presented FCH, and 17 of these were retransplanted, totalling 108 retransplanted patients. Figure 1 shows all cases that led to the final case selection. We also identified 164 patients with hepatic decompensation who did not undergo reLT (141 with F3 or F4 and 23 with FCH) prior to the data collection period. The centre-based distribution of advanced fibrosis and FCH cases with and without reLT is described in Table 1. The mean interval elapsing between reLT re-listing and actual reLT was 151 d (1-1393), with no statistical difference between the groups (*p* = 0.22). Explants revealed concomitant chronic rejection in three cases, non-alcoholic steatohepatitis in one case and hepatocarcinoma in one case. In all other cases, HCV recurrence was the only diagnosis that led to reLT.

***Demographic and clinical characteristics***

The principal clinical and demographic characteristics of the reLT patients were: mean age at LT1 of 48 ± 8 years; mean age at reLT of 54 ± 8 years; 81 (75%) were men; mean donor age at LT1 of 51 ± 15 years; mean donor age at reLT of 44 ± 16 years; none of the donors were seropositive for HCV; concomitant alcoholic disease in 20 patients (18%); HIV co-infection in four (4%); HCC at LT1 in 40 (37%); 84 patients (78%) presented with F4 after LT1, 18 (17%) presented with FCH, and six (5%) presented with F3 and clinical hepatic decompensation; 26 patients (25%) received corticosteroid bolus after LT1. The mean interval between LT1 and decompensation was 4.4 years (0.1-16.0). The mean interval between LT1 and reLT was 5.5 years (0.1-17.8). The mean MELD score 20-30 d after decompensation was 21 ± 7, and the mean MELD score before reLT was 24.5 ± 8.4. The first decompensation presented as ascites in 68 patients (68%), encephalopathy in 12 (12%), jaundice in 10 (10%), and variceal haemorrhage in nine (9%).

***Survival and prognostic factors***

Patient survival rates in the reLT group were 55%, 47%, and 43% at 3, 5, and 10 years, respectively, after the date of reLT. Patients who were retransplanted for advanced cirrhosis had survival rates of 59%, 52%, and 49% at 3, 5, and 10 years, while those retransplanted for FCH had survival rates of 34%, 29%, and 11%, respectively.

There were 28 cases of reLT before 2003, and 80 cases between 2003 and 2012. There was no statistical difference when survival was compared between these two periods (*p* = 0.26).

Fourteen patients presented with an SVR after LT1. The survival rate in this group of patients was 86% at 5 years (12/14 patients), with a median reLT donor age of 44 years (14-62) and a median MELD score of 24 (14-38) (Table 2).

The risk factors associated with better survival under univariate analysis are shown in Tables 3 and 4. An Andrés score lower than 40 was significantly associated with better survival under univariate analysis but not under multivariate analysis. Factors associated with survival under multivariate analysis are shown in Table 5, which concerns the 83 patients for whom all variables found to be significant under univariate analysis were available. Data were adjusted for the centre effect and for the occurrence of FCH after LT1.

The causes of death among the 55/108 patients (51%) in the reLT group were as follows: septic shock of bacterial origin in 17 (31%), liver failure due to HCV recurrence in nine (16%), surgical complications during the perioperative period in seven (13%), haemorrhage in five (9%), multiorgan failure in four (7%), heart failure in two (4%), septic shock of fungal origin in two (4%), and other causes in eight (16%) (one case each of lymphoproliferative disorder, pulmonary embolism, renal insufficiency, septic shock of mycobacterial origin, non-liver solid cancer, and four unknown).

***Estimation of survival***

An estimate of survival was calculated, based on the presence of the five independent predictors of survival (Table 6). This table highlights two situations that underline the importance of HCV therapy after reLT. If modifiable factors were taken into account and a donor younger than 60 years was used, with the patient receiving antiviral treatment after reLT, estimated survival at 5 years at 73%. In contrast, the same situation but with no treatment after reLT generated a survival rate of only 18% at 5 years.

***Application of the score***

The Andrés score was applied to the 102 patients for whom all score variables were available (in six patients, pre-reLT albumin values were not available), and this produced a mean score of 43.4 (SD = 6.6).

***Natural history***

In the reLT group, 18/108 patients (17%) presented with FCH after the first LT. Of these, 5/18 (28%) progressed to FCH after reLT (*p* = 0.11). Of the remaining 90/108 (83%) who did not present with FCH after LT1, six (7%) progressed to FCH after reLT.

In 52 patients with available pre and post-reLT biopsies, the mean fibrosis progression rate was 2.28 (0.27-16) Metavir units/year after LT1, compared to 1.49 (0-6.0) Metavir units/year after reLT (*p* = 0.051). Of these, 13 (25%) received antiviral therapy before reLT (four patients presented with an SVR), and 11 (21%) received antiviral therapy after reLT (seven presented with an SVR).

Fifty-six of the remaining patients were not included in the analysis for the fibrosis progression rate for the following reasons: five did not undergo biopsies before reLT (so that the precise timing of fibrosis was not determined), 51 did not present biopsies with fibrosis after reLT (23 died within 90 d of reLT, six underwent biopsies that revealed lobular hepatitis, five had biopsies showing FCH, five had undetectable levels of HCV viremia before reLT, two presented with a sustained virological response after antiviral therapy following reLT, and ten for unknown reasons).

***No reLT group***

Survival rates after the date of the first decompensation post-LT1 in the reLT group (94 patients decompensated) at 3, 5, and 10 years, were 59%, 55%, and 46% respectively. In the non-reLT group with hepatic decompensation, survival rates were 27%, 18%, and 9% at 3, 5, and 10 years, respectively (*p* < 0.0001).

Compared to non-retransplanted patients, retransplanted patients were younger at LT1 (mean age 48 ± 8 years compared to 53 ± 9 in the no reLT group, *p* < 0.0001), less likely to have HIV co-infection (4% compared to 14% in the no reLT group, *p* = 0.005), more likely to have received corticosteroid bolus after LT1 (25% in the reLT versus 12% in the no reLT group, *p* = 0.01), and to have presented with an SVR after the first transplantation (20% in reLT group versus 7% in no reLT group, *p* = 0.028) (the data refer to 71 treatments in reLT group and 87 treatments in the no reLT group). Variables found to be similar in both groups included: acute rejection episodes after LT1, use of OKT3 after LT1, number of antiviral treatments, results of biochemical and haematological investigations up to 30 d after hepatic decompensation following LT1 (bilirubin, creatinine, INR, haemoglobin, platelets, sodium and albumin), genotype distribution, type of antiviral treatment, treatment duration, rates of treatment discontinuation.

In the non-reLT group with hepatic decompensation, 20 (12.1%) of the 164 patients were re-listed or were undergoing a pre-reLT work-up for relisting at the time of data collection. The reasons for not replacing the remaining 144 patients on the waiting list were: death due to hepatic decompensation before relisting (30.6%), clinically considered as unsuitable because of hepatic, cardiac, renal, neurological, psychiatric or other systemic diseases (22.9%), advanced age (over 70 years) (11.8%), *de novo* cancer or HCC recurrence (6.9%), alcohol consumption (4.9%), stable without further decompensation (4.2%), under antiviral therapy at the time of data collection and would be considered for reLT depending on outcome (2.4%), poor compliance (2.8%), stabilised after a sustained virological response (1.4%), patient refused reLT (0.7%), reLT not possible due to surgical impediments (0.7%) and unknown (10.8%). The mean follow-up period was of 5796 d (62-9541).

**Discussion**

This multicentre and retrospective study is the first non-registry study to have been performed on reLT because of HCV recurrence in a large number of patients. Furthermore, it is also the first to have analysed detailed virological data and antiviral therapies in this population, giving great importance to this factor when selecting patients with HCV recurrence for reLT, especially in the current era of direct-acting antivirals. In this context, the principal prognostic factors associated with the survival in our cohort were: negative HCV viremia before reLT, antiviral therapy after reLT, non-genotype 1, re-listing at MELD below 25, and a reLT donor age < 60 years. The non-retransplanted group was helpful in trying to explain the selection bias for and against an indication for reLT, as the decision to retransplant a patient with HCV recurrence depended on each centre’s policies.

The most important contribution of our study is the evidence it provides concerning the considerable influence of antiviral therapy before and after reLT. Previous studies had already demonstrated the importance of treating HCV before and after LT1[38–47]. During the period of our study, the new drugs that became available were protease inhibitors, and we included only 1 patient under sofosbuvir, one of the newer direct-acting antivirals. In the modern era of direct-acting antivirals, encouraging results have been achieved using IFN-free HCV regimens in the population of patients with advanced cirrhosis on the waiting list, with high SVR rates and low rates of serious adverse events requiring treatment discontinuation[48,49]. Studies of post-LT treatment with the new DAAs studies have demonstrated SVR rates ranging from 70%-94%[49–53]. Although the numbers in our study are small, we were also able to show that in the 14 patients undergoing reLT with undetectable HCV viremia, the reLT donor age and MELD score did not influence outcome. In the long-term, early antiviral treatment post-LT may become the standard-of-care and reduce the occurrence of advanced graft cirrhosis. However, the subpopulations of individuals presenting with genotype 3, end-stage renal disease and resistance to DAAs remain a concern.

Several early studies had described high mortality rates in individuals retransplanted for HCV recurrence[25,26], with more recent studies producing survival rates similar to ours[27,54]. Our reLT survival rates of 55%, 47%, and 43% at 3, 5, and 10 years, respectively, were not excessively disappointing given the LT survival rates for HCV cirrhosis alone reported in the literature, which average 75%, 65% and 52% at 1, 3 and 5 years[55]. A minimum acceptable threshold for graft survival is difficult to define[56]. Previous meetings have suggested a minimum 5-year survival of 50% for reLT[57]. At 5 years, the patients in our cohort achieved a 47% survival rate, but no defined criteria for re-listing were applied. Better patient selection should therefore improve survival. Although the survival of the four HIV co-infected patients after reLT was extremely poor (no patient was alive at 3 years), in the context of new DAA, the response rates are promising in the non-transplanted population[58,59]. In a recent multicentre study on reLT in HIV-infected individuals, only four patients experienced an HCV recurrence requiring reLT, even though DAAs were not yet available[60]. Regarding the disappointing survival rates seen in non retransplanted patients compared to those undergoing reLT, many factors may have influenced this result, such as higher rates of SVR in the reLT group and possibly higher rates of comorbidities leading to contraindications for reLT.

In McCashland’s study[27], although the MELD score was not predictive of survival, higher MELD scores pre-reLT (> 25) were associated with mortality rates. However, that study was not designed to analyse predictive factors for survival. Our data analyses found that relisting with a MELD > 25 was associated with a poor prognosis, but not the MELD score before reLT. In their no-reLT group with decompensated HCV recurrence, survival reached 47% at 3 years, compared to 27% in our study. The percentage of relisted patients in their study was similar to our findings (15% *vs* 12%).

One known factor for better survival in the setting of HCV-related diseases is donor age[61], and our data confirmed this finding in the context of reLT. Our estimation of survival not only evidenced the importance of antiviral therapy but also the impact of donor age. This triggers another discussion regarding the futility of the procedure in an era of young donor shortages[62]. Although the numbers are small, we also showed that outcomes in patients who underwent reLT with undetectable HCV viremia did not depend on donor age. This issue warrants future evaluation in the context of the availability of new antivirals.

In the registry study by Andres *et al*[29], which proposed the score applied to our patients, several variables were not available from this registry, such as HCV genotype, level of viremia, type of anti-HCV treatment or biopsy scores, all of which could have markedly affected survival. In our study, patients with an Andres score over 40 had a 5-year survival rate of 40%, compared to an estimated survival of 27% in their cohort. One possible explanation for these discrepant results may have been their inclusion criteria (more than 30 d after reLT for all HCV-positive retransplanted cases), so that they did not solely include patients with HCV recurrence. Also, our cohort may have included more severely ill patients. Our study was not designed to validate the score, as statistically the number of cases was still too small to offer new thresholds. Other previously published scores had either not been designed specifically for reLT in the event of HCV recurrence[12,32] or were derived from LT1 cases and then extended to reLT, so therefore did not focus on this population[14].

Our study did have some limitations. Considering that surgical techniques, immunossuppression regimens, antiviral treatment, anaesthesiology and intensive care have changed over the years, the long period we covered which could have influenced survival. However, the survival rates were similar when our analysis compared reLT before and after 2003. Although our study included data from eight different liver transplantation centres, two of them contributed more than half of the reLT cases (57/108; 53%). As these two centres could be considered as being more experienced in this technique, an analysis was performed after adjusting for the centre effect. No uniform criteria exist for reLT indication in HCV recurrence, and each centre adopted its own policies. This also applied to antiviral therapy before and after reLT. Another limitation was that the identification of cases for the non-reLT group was based on histological biopsies post-LT1, but because one centre did not perform protocol biopsies, this group may have been under-represented. Furthermore, FCH was defined according to the pathologist’s report, and hence may not have strictly followed previously accepted definitions of FCH[63–65].

In conclusion, reLT in the context of HCV recurrence requires careful patient selection. From this present study, the first to analyse such detailed virological and treatment data, we can conclude that antiviral therapy both before and after reLT can play an important role when deciding whether to retransplant or not. In an era of new direct-acting antivirals agents, the scenario of retransplantation for HCV recurrence will most likely change dramatically in the future. The findings of our study could nevertheless be useful in the medium term while HCV recurrence is still prevalent, and also in limited-resource settings where direct-acting antivirals are not yet available.

**AcknowledgEments**

We wish to thank Victoria Hawken for revising the English language of this paper.

**COMMENTS**

***Background***

Advanced liver disease caused by hepatitis C virus (HCV) is the leading cause of liver transplantation (LT) in Western countries. Histologically documented chronic hepatitis C develops in approximately 70% of patients during the first year after LT. Progression of this disease is particularly aggressive in transplanted patients, with a rapid evolution towards fibrosis when compared to immunocompetent individuals, resulting in graft loss due to recurrent disease. In patients with established cirrhosis and graft failure, retransplantation (reLT) is the only therapeutic option. But because of organ shortages, cost issues and poorer survival, the indications for reLT must be appropriate. In previous studies, HCV-related disease did not indicate a poorer prognosis following reLT, while other studies have identified HCV recurrence as an independent predictive factor for mortality. But few studies have evaluated risk factors for mortality among patients retransplanted for HCV recurrence.

***Research frontiers***

Retransplantation for HCV recurrence has been a controversial issue because of the possibility of poorer survival compared to other indications. The published literature is scarce on this topic, as there are currently no formal recommendations as to which patients should undergo retransplantation in this context. A multicentre study was performed in order to analyse survival factors in this population.

***Innovations and breakthrough***

This is the first study to have been published with a fair number of retransplantations for HCV recurrence having been analysed in terms of virological findings and HCV antiviral therapy as risk factors for a better prognosis. In view of the new era of direct-acting antivirals and donor scarcity, the results of this study should constitute an aid for decision-making in the context of indications for retransplantation.

***Applications***

In this new era of direct-acting antivirals and donor scarcity, the results of this study should aid with decision-making in the context of indications for retransplantation.

***Terminology***

The recurrence of hepatitis C is universal among individuals transplanted for HCV-related cirrhosis and with a positive viral load prior to transplantation. Retransplantation may be indicated in those who progress to cirrhosis after HCV recurrence on the graft.

***Peer-review***

This is a very important topic in the era of chronic organ shortage. The authors have very nicely written a review of 108 patients retransplanted for HCV recurrence in eight European liver transplantation centers and analyzed the factors associated with survival in this population.

**References**

1 **Rubín A**, Aguilera V, Berenguer M. Liver transplantation and hepatitis C. *Clin Res Hepatol Gastroenterol* 2011; **35**: 805-812 [PMID: 21963086 DOI: 10.1016/j.clinre.2011.04.009]

2 **Song AT**, Avelino-Silva VI, Pecora RA, Pugliese V, D'Albuquerque LA, Abdala E. Liver transplantation: fifty years of experience. *World J Gastroenterol* 2014; **20**: 5363-5374 [PMID: 24833866 DOI: 10.3748/wjg.v20.i18.5363]

3 **Berenguer M**. Natural history of recurrent hepatitis C. *Liver Transpl* 2002; **8**: S14-S18 [PMID: 12362293 DOI: 10.1053/jlts.2002.35781]

4 **Saab S**, Wang V. Recurrent hepatitis C following liver transplant: diagnosis, natural history, and therapeutic options. *J Clin Gastroenterol* 2003; **37**: 155-163 [PMID: 12869888]

5 **Gane EJ**. The natural history of recurrent hepatitis C and what influences this. *Liver Transpl* 2008; **14**: S36–S44 [PMID: 18825724 DOI: 10.1002/lt.21646]

6 **Rowe IA**, Webb K, Gunson BK, Mehta N, Haque S, Neuberger J. The impact of disease recurrence on graft survival following liver transplantation: a single centre experience. *Transpl Int* 2008; **21**: 459-465 [PMID: 18225996 DOI: 10.1111/j.1432-2277.2007.00628.x]

7 **Berenguer M**, Prieto M, Rayón JM, Mora J, Pastor M, Ortiz V, Carrasco D, San Juan F, Burgueño MD, Mir J, Berenguer J. Natural history of clinically compensated hepatitis C virus-related graft cirrhosis after liver transplantation. *Hepatology* 2000; **32**: 852-858 [PMID: 11003634 DOI: 10.1053/jhep.2000.17924]

8 **Firpi RJ**, Clark V, Soldevila-Pico C, Morelli G, Cabrera R, Levy C, Machicao VI, Chaoru C, Nelson DR. The natural history of hepatitis C cirrhosis after liver transplantation. *Liver Transpl* 2009; **15**: 1063–1071 [PMID: 19718647 DOI: 10.1002/lt.21784]

9 **Azoulay D**, Linhares MM, Huguet E, Delvart V, Castaing D, Adam R, Ichai P, Saliba F, Lemoine A, Samuel D, Bismuth H. Decision for retransplantation of the liver: an experience- and cost-based analysis. *Ann Surg* 2002; **236**: 713-21; discussion 721 [PMID: 12454509 DOI: 10.1097/01.SLA.0000036264.66247.65]

10 Organización Nacional de Transplante (ONT). 2009 Available from: URL: http://www.ont.es

11 **Wong T**, Devlin J, Rolando N, Heaton N, Williams R. Clinical characteristics affecting the outcome of liver retransplantation. *Transplantation* 1997; **64**: 878-882 [PMID: 9326414]

12 **Markmann JF**, Gornbein J, Markowitz JS, Levy MF, Klintmalm GB, Yersiz H, Morrisey M, Drazan K, Farmer DG, Ghobrial RM, Goss J, Seu P, Martin P, Goldstein LI, Busuttil RW. A simple model to estimate survival after retransplantation of the liver. *Transplantation* 1999; **67**: 422-430 [PMID: 10030290]

13 **Markmann JF**, Markowitz JS, Yersiz H, Morrisey M, Farmer DG, Farmer DA, Goss J, Ghobrial R, McDiarmid SV, Stribling R, Martin P, Goldstein LI, Seu P, Shackleton C, Busuttil RW. Long-term survival after retransplantation of the liver. *Ann Surg* 1997; **226**: 408-18; discussion 418-20 [PMID: 9351709]

14 **Ghobrial RM**, Gornbein J, Steadman R, Danino N, Markmann JF, Holt C, Anselmo D, Amersi F, Chen P, Farmer DG, Han S, Derazo F, Saab S, Goldstein LI, McDiarmid SV, Busuttil RW. Pretransplant model to predict posttransplant survival in liver transplant patients. *Ann Surg* 2002; **236**: 315-22; discussion 322-3 [PMID: 12192318 DOI: 10.1097/01.SLA.0000026684.68004.1E]

15 **Linhares MM**, Azoulay D, Matos D, Castelo-Filho A, Triviño T, Goldenberg A, Castaing D, Adam R, Délvart V, Ichai P, Saliba F, Lemoine A, Samuel D, Bismuth H. Liver retransplantation: a model for determining long-term survival. *Transplantation* 2006; **81**: 1016-1021 [PMID: 16612278 DOI: 10.1097/01.tp.0000203798.96491.2f]

16 **Crivellin C**, De Martin E, Germani G, Gambato M, Senzolo M, Russo FP, Vitale A, Zanus G, Cillo U, Burra P. Risk factors in liver retransplantation: a single-center experience. *Transplant Proc* 2011; **43**: 1110-1113 [PMID: 21620065 DOI: 10.1016/j.transproceed.2011.01.141]

17 **Remiszewski P**, Kalinowski P, Dudek K, Grodzicki M, Paluszkiewicz R, Zieniewicz K, Krawczyk M. Influence of selected factors on survival after liver retransplantation. *Transplant Proc* 2011; **43**: 3025-3028 [PMID: 21996216 DOI: 10.1016/j.transproceed.2011.08.026]

18 **Yao FY**, Saab S, Bass NM, Hirose R, Ly D, Terrault N, Lazar AA, Bacchetti P, Ascher NL, Roberts JP. Prediction of survival after liver retransplantation for late graft failure based on preoperative prognostic scores. *Hepatology* 2004; **39**: 230-238 [PMID: 14752842 DOI: 10.1002/hep.20005]

19 **Ghabril M**, Dickson R, Wiesner R. Improving outcomes of liver retransplantation: an analysis of trends and the impact of Hepatitis C infection. *Am J Transplant* 2008; **8**: 404-411 [PMID: 18211509 DOI: 10.1111/j.1600-6143.2007.02082.x]

20 **Ghobrial RM**, Steadman R, Gornbein J, Lassman C, Holt CD, Chen P, Farmer DG, Yersiz H, Danino N, Collisson E, Baquarizo A, Han SS, Saab S, Goldstein LI, Donovan JA, Esrason K, Busuttil RW. A 10-year experience of liver transplantation for hepatitis C: analysis of factors determining outcome in over 500 patients. *Ann Surg* 2001; **234**: 384-93; discussion 393-4 [PMID: 11524591]

21 **Bahra M**, Neumann UP, Jacob D, Berg T, Neuhaus R, Langrehr JM, Neuhaus P. Outcome after liver re-transplantation in patients with recurrent chronic hepatitis C. *Transpl Int* 2007; **20**: 771-778 [PMID: 17617179 DOI: 10.1111/j.1432-2277.2007.00517.x]

22 **Yoo HY**, Maheshwari A, Thuluvath PJ. Retransplantation of liver: primary graft nonfunction and hepatitis C virus are associated with worse outcome. *Liver Transpl* 2003; **9**: 897-904 [PMID: 12942450 DOI: 10.1053/jlts.2003.50176]

23 **Roayaie S**, Schiano TD, Thung SN, Emre SH, Fishbein TM, Miller CM, Schwartz ME. Results of retransplantation for recurrent hepatitis C. *Hepatology* 2003; **38**: 1428-1436 [PMID: 14647054 DOI: 10.1016/j.hep.2003.09.010]

24 **Pelletier SJ**, Schaubel DE, Punch JD, Wolfe RA, Port FK, Merion RM. Hepatitis C is a risk factor for death after liver retransplantation. *Liver Transpl* 2005; **11**: 434-440 [PMID: 15776460 DOI: 10.1002/lt.20342]

25 **Berenguer M**, Prieto M, Palau A, Rayón JM, Carrasco D, Juan FS, López-Labrador FX, Moreno R, Mir J, Berenguer J. Severe recurrent hepatitis C after liver retransplantation for hepatitis C virus-related graft cirrhosis. *Liver Transpl* 2003; **9**: 228-235 [PMID: 12619018 DOI: 10.1053/jlts.2003.50029]

26 **Carmiel-Haggai M**, Fiel MI, Gaddipati HC, Abittan C, Hossain S, Roayaie S, Schwartz ME, Gondolesi G, Emre S, Schiano TD. Recurrent hepatitis C after retransplantation: Factors affecting graft and patient outcome. *Liver Transpl* 2005; **11**: 1567–1573 [PMID: 16315297 DOI: 10.1002/lt.20517]

27 **McCashland T**, Watt K, Lyden E, Adams L, Charlton M, Smith AD, McGuire BM, Biggins SW, Neff G, Burton JR, Vargas H, Donovan J, Trotter J, Faust T. Retransplantation for hepatitis C: results of a U.S. multicenter retransplant study. *Liver Transpl* 2007; **13**: 1246-1253 [PMID: 17763405 DOI: 10.1002/lt.21322]

28 **Rowe IA**, Barber KM, Birch R, Curnow E, Neuberger JM. Retransplantation for graft failure in chronic hepatitis C infection: a good use of a scarce resource? *World J Gastroenterol* 2010; **16**: 5070-5076 [PMID: 20976844 DOI: 10.3748/wjg.v16.i40.5070]

29 **Andres A**, Gerstel E, Combescure C, Asthana S, Merani S, Majno P, Berney T, Morel P, Kneteman N, Mentha G, Toso C. A score predicting survival after liver retransplantation for hepatitis C virus cirrhosis. *Transplantation* 2012; **93**: 717-722 [PMID: 22267157 DOI: 10.1097/TP.0b013e318246f8b3]

30 **Carrión JA**, Navasa M, Forns X. Retransplantation in patients with hepatitis C recurrence after liver transplantation. *J Hepatol* 2010; **53**: 962-970 [PMID: 20800307 DOI: 10.1016/j.jhep.2010.06.006]

31 **Hong JC**, Kaldas FM, Kositamongkol P, Petrowsky H, Farmer DG, Markovic D, Hiatt JR, Busuttil RW. Predictive index for long-term survival after retransplantation of the liver in adult recipients: analysis of a 26-year experience in a single center. *Ann Surg* 2011; **254**: 444-48; discussion 444-48; [PMID: 21817890 DOI: 10.1097/SLA.0b013e31822c5878]

32 **Rosen HR**, Madden JP, Martin P. A model to predict survival following liver retransplantation. *Hepatology* 1999; **29**: 365-370 [PMID: 9918911 DOI: 10.1002/hep.510290221]

33 **Burton JR**, Rosen HR. Liver retransplantation for hepatitis C virus recurrence: a survey of liver transplant programs in the United States. *Clin Gastroenterol Hepatol* 2005; **3**: 700-704 [PMID: 16206504]

34 **Hofmann WP**, Sarrazin C, Zeuzem S. Current standards in the treatment of chronic hepatitis C. *Dtsch Arztebl Int* 2012; **109**: 352-358 [PMID: 22675406 DOI: 10.3238/arztebl.2012.0352]

35 **Poynard T**, Bedossa P, Opolon P. Natural history of liver fibrosis progression in patients with chronic hepatitis C. The OBSVIRC, METAVIR, CLINIVIR, and DOSVIRC groups. *Lancet* 1997; **349**: 825-832 [PMID: 9121257]

36 **Breslow N**. Covariance analysis of censored survival data. *Biometrics* 1974; **30**: 89-99 [PMID: 4813387]

37 **Watt KD**, Lyden ER, McCashland TM. Poor survival after liver retransplantation: is hepatitis C to blame? *Liver Transpl* 2003; **9**: 1019-1024 [PMID: 14526394 DOI: 10.1053/jlts.2003.50206]

38 **Iacobellis A**, Siciliano M, Perri F, Annicchiarico BE, Leandro G, Caruso N, Accadia L, Bombardieri G, Andriulli A. Peginterferon alfa-2b and ribavirin in patients with hepatitis C virus and decompensated cirrhosis: a controlled study. *J Hepatol* 2007; **46**: 206–212 [PMID: 17125876 DOI: 10.1016/j.jhep.2006.08.020]

39 **Carrión JA**, Martínez-Bauer E, Crespo G, Ramírez S, Pérez-del-Pulgar S, García-Valdecasas JC, Navasa M, Forns X. Antiviral therapy increases the risk of bacterial infections in HCV-infected cirrhotic patients awaiting liver transplantation: A retrospective study. *J Hepatol* 2009; **50**: 719-728 [PMID: 19217183 DOI: 10.1016/j.jhep.2008.11.015]

40 **Everson GT**, Terrault NA, Lok AS, Rodrigo del R, Brown RS Jr, Saab S, Shiffman ML, Al-Osaimi AM, Kulik LM, Gillespie BW, Everhart JE. A randomized controlled trial of pretransplant antiviral therapy to prevent recurrence of hepatitis C after liver transplantation. *Hepatology* 2013; **57**: 1752-1762 [PMID: 22821361 DOI: 10.1002/hep.25976]

41 **Forns X**, García-Retortillo M, Serrano T, Feliu A, Suarez F, de la Mata M, García-Valdecasas JC, Navasa M, Rimola A, Rodés J. Antiviral therapy of patients with decompensated cirrhosis to prevent recurrence of hepatitis C after liver transplantation. *J Hepatol* 2003; **39**: 389-396 [PMID: 12927925]

42 **Berenguer M**, Schuppan D. Progression of liver fibrosis in post-transplant hepatitis C: mechanisms, assessment and treatment. *J Hepatol* 2013; **58**: 1028-1041 [PMID: 23262248 DOI: 10.1016/j.jhep.2012.12.014]

43 **Roche B**, Sebagh M, Canfora ML, Antonini T, Roque-Afonso AM, Delvart V, Saliba F, Duclos-Vallee JC, Castaing D, Samuel D. Hepatitis C virus therapy in liver transplant recipients: response predictors, effect on fibrosis progression, and importance of the initial stage of fibrosis. *Liver Transpl* 2008; **14**: 1766-1777 [PMID: 19025933 DOI: 10.1002/lt.21635]

44 **Berenguer M**, Roche B, Aguilera V, Duclos-Vallée JC, Navarro L, Rubín A, Pons JA, de la Mata M, Prieto M, Samuel D. Efficacy of the retreatment of hepatitis C virus infections after liver transplantation: role of an aggressive approach. *Liver Transpl* 2013; **19**: 69-77 [PMID: 23008144 DOI: 10.1002/lt.23555]

45 **Ponziani FR**, Milani A, Gasbarrini A, Zaccaria R, Viganò R, Iemmolo RM, Donato MF, Rendina M, Toniutto P, Pasulo L, Cescon M, Burra P, Miglioresi L, Merli M, Paolo DD, Fagiuoli S, Pompili M. Treatment of genotype-1 hepatitis C recurrence after liver transplant improves survival in both sustained responders and relapsers. *Transpl Int* 2013; **26**: 281-289 [PMID: 23230956 DOI: 10.1111/tri.12027]

46 **Tanaka T**, Selzner N, Therapondos G, Renner EL, Lilly LB. Virological response for recurrent hepatitis C improves long-term survival in liver transplant recipients. *Transpl Int* 2013; **26**: 42-49 [PMID: 23137287 DOI: 10.1111/j.1432-2277.2012.01571.x]

47 **Filipec Kanizaj T**, Kunac N. Hepatitis C: New challenges in liver transplantation. *World J Gastroenterol* 2015; **21**: 5768-5777 [PMID: 26019441 DOI: 10.3748/wjg.v21.i19.5768]

48 **Verna EC**, Burton JR, O’Leary JG, Lai JC, Saxena V, Dodge JL, Everson GT, et al. A multicenter study of protease inhibitor-triple therapy in HCV-infected liver transplant recipients: report from the CRUSH-C Group [Abstract]. *J Hepatol* 2013; **58**: S10–S11 [DOI: [10.1016/S0168-8278(13)60025-2](http://dx.doi.org/10.1016/S0168-8278(13)60025-2)]

49 **Charlton M**, Gane E, Manns MP, Brown RS, Curry MP, Kwo PY, Fontana RJ, Gilroy R, Teperman L, Muir AJ, McHutchison JG, Symonds WT, Brainard D, Kirby B, Dvory-Sobol H, Denning J, Arterburn S, Samuel D, Forns X, Terrault NA. Sofosbuvir and ribavirin for treatment of compensated recurrent hepatitis C virus infection after liver transplantation. *Gastroenterology* 2015; **148**: 108-117 [PMID: 25304641 DOI: 10.1053/j.gastro.2014.10.001]

50 **Pungpapong S**, Aqel B, Leise M, Werner KT, Murphy JL, Henry TM, Ryland K, Chervenak AE, Watt KD, Vargas HE, Keaveny AP. Multicenter experience using simeprevir and sofosbuvir with or without ribavirin to treat hepatitis C genotype 1 after liver transplant. *Hepatology* 2015; **61**: 1880-1886 [PMID: 25722203 DOI: 10.1002/hep.27770]

51 **Gutierrez JA**, Carrion AF, Avalos D, O'Brien C, Martin P, Bhamidimarri KR, Peyton A. Sofosbuvir and simeprevir for treatment of hepatitis C virus infection in liver transplant recipients. *Liver Transpl* 2015; **21**: 823-830 [PMID: 25825070 DOI: 10.1002/lt.24126]

52 **Kwo PY**, Mantry PS, Coakley E, Te HS, Vargas HE, Brown R, Gordon F, Levitsky J, Terrault NA, Burton JR, Xie W, Setze C, Badri P, Pilot-Matias T, Vilchez RA, Forns X. An interferon-free antiviral regimen for HCV after liver transplantation. *N Engl J Med* 2014; **371**: 2375-2382 [PMID: 25386767 DOI: 10.1056/NEJMoa1408921]

53 **Righi E**, Londero A, Carnelutti A, Baccarani U, Bassetti M. Impact of new treatment options for hepatitis C virus infection in liver transplantation. *World J Gastroenterol* 2015; **21**: 10760-10775 [PMID: 26478668 DOI: 10.3748/wjg.v21.i38.10760]

54 **Martí J**, De la Serna S, Crespo G, Forns X, Ferrer J, Fondevila C, Navasa M, Fuster J, García-Valdecasas JC. Graft and viral outcomes in retransplantation for hepatitis C virus recurrence and HCV primary liver transplantation: a case-control study. *Clin Transplant* 2014; **28**: 821-828 [PMID: 24806099 DOI: 10.1111/ctr.12385]

55 **Burra P**, Senzolo M, Adam R, Delvart V, Karam V, Germani G, Neuberger J. Liver transplantation for alcoholic liver disease in Europe: a study from the ELTR (European Liver Transplant Registry). *Am J Transplant* 2010; **10**: 138-148 [PMID: 19951276 DOI: 10.1111/j.1600-6143.2009.02869.x]

56 **Neuberger J**, James O. Guidelines for selection of patients for liver transplantation in the era of donor-organ shortage. *Lancet* 1999; **354**: 1636-1639 [PMID: 10560692 DOI: 10.1016/S0140-6736(99)90002-8]

57 **Olthoff KM**, Brown RS, Delmonico FL, Freeman RB, McDiarmid SV, Merion RM, Millis JM, Roberts JP, Shaked A, Wiesner RH, Lucey MR. Summary report of a national conference: Evolving concepts in liver allocation in the MELD and PELD era. December 8, 2003, Washington, DC, USA. *Liver Transpl* 2004; **10**: A6-22 [PMID: 15382225 DOI: 10.1002/lt.20247]

58 **Sulkowski MS**, Eron JJ, Wyles D, Trinh R, Lalezari J, Wang C, Slim J, Bhatti L, Gathe J, Ruane PJ, Elion R, Bredeek F, Brennan R, Blick G, Khatri A, Gibbons K, Hu YB, Fredrick L, Schnell G, Pilot-Matias T, Tripathi R, Da Silva-Tillmann B, McGovern B, Campbell AL, Podsadecki T. Ombitasvir, paritaprevir co-dosed with ritonavir, dasabuvir, and ribavirin for hepatitis C in patients co-infected with HIV-1: a randomized trial. *JAMA* 2015; **313**: 1223-1231 [PMID: 25706092 DOI: 10.1001/jama.2015.1328]

59 **Osinusi A**, Townsend K, Kohli A, Nelson A, Seamon C, Meissner EG, Bon D, Silk R, Gross C, Price A, Sajadi M, Sidharthan S, Sims Z, Herrmann E, Hogan J, Teferi G, Talwani R, Proschan M, Jenkins V, Kleiner DE, Wood BJ, Subramanian GM, Pang PS, McHutchison JG, Polis MA, Fauci AS, Masur H, Kottilil S. Virologic response following combined ledipasvir and sofosbuvir administration in patients with HCV genotype 1 and HIV co-infection. *JAMA* 2015; **313**: 1232-1239 [PMID: 25706232 DOI: 10.1001/jama.2015.1373]

60 **Agüero F**, Rimola A, Stock P, Grossi P, Rockstroh JK, Agarwal K, Garzoni C, Barcan LA, Maltez F, Manzardo C, Mari M, Ragni MV, Anadol E, Di Benedetto F, Nishida S, Gastaca M, Miró JM; FIPSE/NIH HIVTR/NEAT023 Investigators. Liver Retransplantation in Patients With HIV-1 Infection: An International Multicenter Cohort Study. *Am J Transplant* 2015; Epub ahead of print [PMID: 26415077 DOI: 10.1111/ajt.13461]

61 **Gitto S**, Belli LS, Vukotic R, Lorenzini S, Airoldi A, Cicero AF, Vangeli M, Brodosi L, Panno AM, Di Donato R, Cescon M, Grazi GL, De Carlis L, Pinna AD, Bernardi M, Andreone P. Hepatitis C virus recurrence after liver transplantation: a 10-year evaluation. *World J Gastroenterol* 2015; **21**: 3912-3920 [PMID: 25852276 DOI: 10.3748/wjg.v21.i13.3912]

62 **Biggins SW**. Futility and rationing in liver retransplantation: when and how can we say no? *J Hepatol* 2012; **56**: 1404-1411 [PMID: 22314427 DOI: 10.1016/j.jhep.2011.11.027]

63 **Wiesner RH**, Sorrell M, Villamil F. Report of the first International Liver Transplantation Society expert panel consensus conference on liver transplantation and hepatitis C. *Liver Transpl* 2003; **9**: S1-S9 [PMID: 14586888 DOI: 10.1053/jlts.2003.50268]

64 **Verna EC**, Abdelmessih R, Salomao MA, Lefkowitch J, Moreira RK, Brown RS. Cholestatic hepatitis C following liver transplantation: an outcome-based histological definition, clinical predictors, and prognosis. *Liver Transpl* 2013; **19**: 78-88 [PMID: 23081888 DOI: 10.1002/lt.23559]

65 **Moreira RK**, Salomao M, Verna EC, Brown RS Jr, Lefkowitch JH. The Hepatitis Aggressiveness Score (HAS): a novel classification system for post-liver transplantation recurrent hepatitis C. *Am J Surg Pathol* 2013; **37**: 104-113 [PMID: 23060356 DOI: 10.1097/PAS.0b013e31826a92ac]

**P-Reviewer:** Bramhall S, Brandao ABD, Fuster J **S-Editor:** Gong ZM

**L-Editor:** **E-Editor:**

**Table 1 Distribution of hepatitis C virus-related cases of advanced fibrosis/ fibrosing cholestatic hepatitis cases after liver transplantation with and without liver retransplantation according to center *n* (%)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Center** | ***n* (LT)** | **LT related to HCV (percent of total LT)** | **F3/F4/FCH after LT**  **(percent of LT for HCV)** | **F3/F4/FCH reLT**  **(percent of LT for HCV)** | **F3/F4/FCH without ReLT (percent of LT for HCV)** |
| 1 | 1933 | 770 (40) | 174 (23) | 31 (4) | 143 (19) |
| 2 | 2001 | 420 (21) | 108 (26) | 26(6) | 82 (20) |
| 3 | 2124 | 412 (19) | 20 (5) | 12 (3) | 8 (2) |
| 4 | 1477 | 321 (22) | 40 (12) | 11 (3) | 29 (9) |
| 5 | 920 | 247 (27) | 33 (13) | 10 (4) | 23 (9) |
| 6 | 1576 | 141 (9) | 16 (11) | 8 (6) | 8 (6) |
| 7 | 450 | 143 (32) | 16 (11) | 8 (6) | 8 (6) |
| 8 | 860 | 132 (15) | 8 (6) | 2 (2) | 6 (5) |
| Total | 11341 | 2586 (23) | 415 (16) | 108 (4) | 307 (12) |

LT : liver transplantation; reLT: liver retransplantation; HCV : hepatitis C virus; F3: Metavir score F3; F4: Metavir score F4; FCH: fibrosing cholestatic hepatitis.**Table 2 Donor age, MELD score, and outcomes in patients undergoing liver retransplantation for hepatitis C virus recurrence with undetectable hepatitis C virus viremia before liver retransplantation**

|  |  |  |
| --- | --- | --- |
| **reLT donor age (yr)** | **reLT MELD score** | **Outcome** |
| 14 | 35 | alive |
| 19 | 22 | deceased |
| 20 | 24 | alive |
| 23 | 16 | alive |
| 24 | 25 | alive |
| 31 | 17 | alive |
| 35 | 23 | alive |
| 46 | 33 | deceased |
| 47 | 38 | alive |
| 52 | 26 | alive |
| 58 | 21 | alive |
| 60 | 28 | alive |
| 62 | 14 | alive |

reLT: liver retransplantation; MELD: Model for End-stage Liver Disease.

**Table 3 Univariate analysis of qualitative variables associated with survival in retransplanted patients for hepatitis C virus recurrence**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Risk factor** | ***n*** | **Survival estimation** | | | **Log-rank *p* value** |
| **3 yr** | **5 yr** | **10 yr** |
| HIV serology  Negative  Positive | 104  4 | 57%  0% | 49% | 45% | 0.006 |
| IS after LT1  without MMF  with MMF | 82  26 | 58%  45% | 51%  33% | 47%  0% | 0.06 |
| Genotype 1  No  Yes | 23  69 | 69%  55% | 69%  45% | 69%  41% | 0.11 |
| HCV viremia pre-reLT  Negative  Positive | 14  94 | 86%  50% | 86%  41% | 86%  36% | 0.005 |
| Dialysis pre-reLT  Yes  No | 19  89 | 74%  51% | 67%  43% | 67%  37% | 0.06 |
| Split graft at reLT  No  Yes | 101  7 | 57%  29% | 48%  29% | 44%  0% | 0.06 |
| IS after reLT  With tacrolimus  Without tacrolimus | 62  41 | 67%  43% | 57%  37% | 53%  30% | 0.038 |
| Antiviral therapy post-reLT  Yes  No | 35  63 | 85%  44% | 75%  36% | 64%  36% | 0.0003 |
| Antiviral response post-reLT  SVR  Partial or NR | 14  18 | 93%  77% | 93%  59% | 93%  43% | 0.039 |
| FCH post-LT1  No  Yes | 90  18 | 59%  34% | 52%  23% | 49%  0% | 0.018 |
| Arterial complications post-reLT |  |  |  |  | 0.03 |
| No | 90 | 62% | 53% | 48% |  |
| Yes | 11 | 27% | 27% | 27% |  |
| Andres score > 40  No  Yes | 35  67 | 71%  49% | 64%  40% | 64%  37% | 0.019 |
| Reinscription MELD < 25  No  Yes | 30  72 | 39%  66% | 34%  58% | 34%  51% | 0.026 |

HIV: human immunodeficiency virus; IS: immunosuppression; LT1: first liver transplantation; MMF: Mycophenolate mophetil; HCV: hepatitis C virus; reLT: liver retransplantation; SVR: sustained virological response; NR: non-responder; FCH: fibrosing cholestatic hepatitis; MELD: Model for End-stage Liver Disease.

**Table 4 Univariate analysis of quantitative variables associated with survival in retransplanted patients for hepatitis C virus recurrence**

|  |  |  |  |
| --- | --- | --- | --- |
| **Risk factor** | **Hazard ratio** | **95%CI** | ***p* value** |
| Less days under MV pre-reLT | 1.25 | 1.02-1.52 | 0.031 |
| Lower reLT donor age | 1.02 | 1.00-1.04 | 0.017 |
| Lower recipient age at LT1 | 1.04 | 1.00-1.08 | 0.027 |
| Greater interval between LT1 and reLT | 0.88 | 0.82-0.96 | 0.002 |

MV: mechanical ventilation; reLT: liver retransplantation; LT1: first liver transplantation.

**Table 5 Factors associated with survival according to multivariate analysis in patients undergoing liver retransplantation for hepatitis C virus recurrence, adjusted for center effect and fibrosing cholestatic hepatitis occurrence**

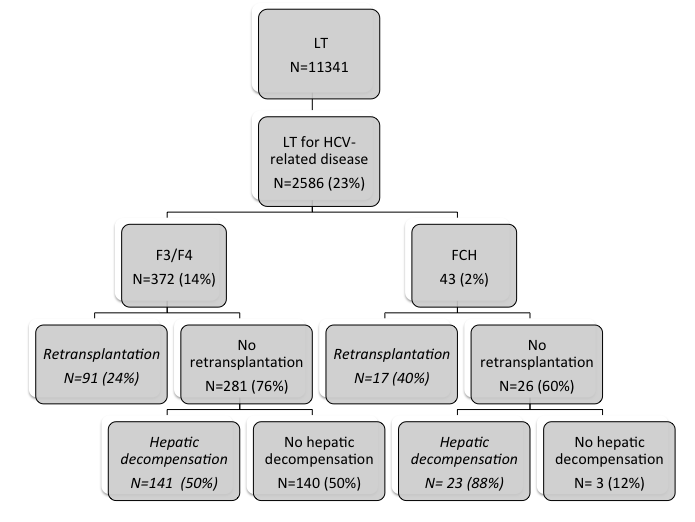
|  |  |  |  |
| --- | --- | --- | --- |
| **Risk factor** | **Hazard ratio** | **95%CI** | ***p* value** |
| Undetectable HCV viremia pre-reLT | 8.80 | 1.96-39.39 | 0.004 |
| Receipt of antiviral treatment after reLT | 4.98 | 2.23-11.15 | < 0.0001 |
| ReLT donor age < 60 yr | 3.54 | 1.42-8.82 | 0.007 |
| Non-genotype 1 | 3.94 | 1.35-11.57 | 0.01 |
| Reinscription MELD ≤  25 | 2.45 | 1.23-4.88 | 0.01 |

HCV: hepatitis C virus; reLT: liver retransplantation; MELD: Model for End-stage Liver Disease.

**Table 6 Survival estimation according to the presence of each of the independent mortality risk factors**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RT inscription MELD > 25** | **Genotype 1** | **RT donor age > 60 yr** | **No antiviral treatment post-RT** | **HCV viremia pre-RT** | **Number of factors** | **Survival 1 yr** | **Survival 3 yr** | **Survival 5 yr** |
| - | - | - | - | - | 0 | 99.7% | 99.5% | 99.3% |
| + | - | - | - | - | 1 | 99.1% | 98.7% | 98.3% |
| - | + | - | - | - | 98.8% | 98.1% | 97.2% |
| - | - | + | - | - | 99.0% | 97.9% | 97.0% |
| - | - | - | + | - | 98.6% | 97,7% | 96,8% |
| - | - | - | - | + | 98.0% | 96.2% | 94.8% |
| + | + | - | - | - | 2 | 97.4% | 95.3% | 94.6% |
| + | - | + | - | - | 97.7% | 95.9% | 94.3% |
| + | - | - | + | - | 96.9% | 95.1% | 93.2% |
| - | + | + | - | - | 96.0% | 93.4% | 90.8% |
| + | - | - | - | + | 95.3% | 91.7% | 88.3% |
| - | + | - | + | - | 94.8% | 91.3% | 87.9% |
| - | - | + | + | - | 94.8% | 90.7% | 87.3% |
| - | + | - | - | + | 91,3% | 85.9% | 81.0% |
| - | - | + | - | + | 91.3% | 85.7% | 79.6% |
| - | - | - | + | + | 87.0% | 79.4% | 71.2% |
| + | + | + | - | - | 3 | 92.3% | 87.8% | 83,2% |
| + | + | - | + | - | 89,4% | 82,5% | 76,4% |
| + | + | - | - | + | 83.2% | 73.1% | 63.9% |
| + | - | + | - | + | 82.5% | 72.1% | 63.1% |
| - | + | + | + | - | 82.0% | 71.2% | 61.9% |
| + | - | - | + | + | 75.2% | 61.4% | 50.3% |
| + | - | + | + | - | 72.5% | 58.1% | 47.0% |
| - | + | + | - | + | 71.1% | 56.3% | 44.5% |
| - | + | - | + | + | 61.2% | 42.7% | 30.2% |
| - | - | + | + | + | 59.9% | 41.6% | 28.5% |
| + | + | + | + | - | 4 | 67.2% | 50.5% | 37.9% |
| + | + | + | - | + | 52.0% | 32.4% | 20.1% |
| + | + | - | + | + | 36.9% | 18.1% | 8.9% |
| + | - | + | + | + | 35.7% | 17.1% | 8.3% |
| - | + | + | + | + | 17.0% | 4.5% | 1.5% |
| + | + | + | + | + | 5 | 2.8% | 0.3% | 0.0% |

HCV: hepatitis C virus; MELD: Model for End-stage Liver Disease.

******

**Figure 1 one hundred and eight retransplanted cases for hepatitis C virus recurrence and 164 not retransplanted F3/F4/** **fibrosing cholestatic hepatitis cases presenting hepatic decompensation (in italics) after inclusion and exclusion criteria were applied.** HCV: hepatitis C virus; F3/F4: Metavir fibrosis score 3/4; FCH: fibrosing cholestatic hepatitis.