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*Original Article*

# Liver dysfunction as an important predicting risk factor in patients undergoing cardiac surgery: a systematic review and meta-analysis

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**Abstract:** Liver function is not considered as a risk factor by current risk scores, such as EUROSCORE II or STS-Score for cardiac surgery. The aim of this study was to review the role of liver dysfunction, classified by the Child-Turcotte-Pugh classification or model for end-stage liver disease scores, as a risk factor for mortality and morbidity of patients following cardiac surgery. The Pubmed referencing library was searched. The rates of mortality and morbidity were calculated using SPSS software. The mortality rates in patients of Child class A, Child class B, and Child class C were pairwise compared respectively. A total of 22 reports including 939 patients from eight countries were reviewed. The mortality rate of patients increased in accordance with increased CTP classification. The lowest mortality rate was recorded in Child class A patients, followed by Child class B patients and the highest mortality rate was observed in Child class C patients. The mean complication rate ranged from 3.82% to 22.15%. Child class C patients should be considered unacceptable for cardiovascular surgery. As two studies revealed, patients with a higher MELD score had significantly higher mortality rates. Liver function should be viewed as an important risk factor for cardiovascular surgery, based on its strong association with mortality and morbidity.

**Keywords:** Liver dysfunction, cardiac surgery, risk model, mortality rate, meta analysis

## Introduction

Liver disease has been reported as a risk factor for mortality and complications following cardiac surgery [1-5]. Advanced liver dysfunction has been shown to increase perioperative mortality as a result of coagulation disorders, haemostatic disorders and bacterial infection [5-7]. Studies have also shown that the risk of complications including infections and impairment of various organs is increased in patients with liver disease undergoing cardiovascular operations [8]. Some current risk scores have been employed to evaluate the risk of operative mortality in cardiac surgery. However, they do not account for liver dysfunction in these surgical risk models [1-5]. For example, two well established cardiac surgical risk prediction models, the Society of Thoracic Surgeons (STS) system and the European System for Cardiac Operative Risk Evaluation (EuroSCORE) model, do not consider liver dysfunction as a surgical risk factor [7]. Consequently, for those patients with poor liver function, such as liver cirrhosis, operative mortality needs to be assessed by specific surgical risk scores.

In clinical practice, it is problematic to distinguish patients who may benefit from cardiac surgery from those whose perioperative risk exceeds benefit. Assessing individual surgical risk for each patient suffering from liver disease preoperatively, and separating patients who may benefit from cardiac surgery from those whose perioperative risk exceeds surgical benefits, using specific risk assessment systems, is vital [6, 9]. The Child-Turcotte-Pugh (CTP) classifications and the model for end-stage liver disease (MELD) scoresare the risk models widely used to determine surgical prognosis in patients with liver disease and can be used to predict operative mortality in these patients [4, 6, 9-12]. Therefore, this study reviews the role of liver dysfunction (classified by CTP or MELD) as a risk factor for mortality and morbidity in cardiac surgery patients.

## Methods

### *Literature search*

The Pubmedreference library was searched from inception to June 1, 2013. The search terms were divided into two parts: disease (heart surgery, cardiac surgery, cardiac operation* and heart operation*) and exposure (liver dysfunction, liver function, and liver disease*). Cardiac surgerylisted under disease included mitral valve replacement, coronary artery bypass, peri-cardiectomy, aortic valve replacement, patch repair, ascending aorta replacement, pseudo lumen closure, tricuspid annuloplasty, aortic root replacement and liver disease listed under exposure included liver transplantation, liver cirrhosis. Two risk assessment systems, Child-Turcotte-Pugh (CTP) scores and the model for end-stage liver disease (MELD) score, were also used as search terms in the exposure search. No restrictions in terms of publication date, language and status were implemented.

### *Inclusion and exclusion criteria*

Published cohort studies, case-reports and case series investigating the role ofliver dysfunctionas a risk factor for mortality and morbidity of cardiac surgery were included. The exclusion criteria included letters, comments and editorials. The reference lists of included studies were analyzed to uncover missing studies. Mortality and morbidity outcomes of the reviewed studies were analyzed.

### *Study selection and data extraction*

Two independent reviewers selected studies to be included in this review according to the predetermined inclusion criteria. Data was analyzed including the basic information of the studies, patient demographics, the duration of follow-up, data about CTP classification and MELD score, and patient mortality and morbidity outcomes.

### *Data analysis and description*

The influence of various degrees of liver dysfunction, as determined by CTP classification on mortality rates after cardiac surgery wasanalyzed. The mortality rate in patients of Child class A was compared with that in patients of Child class B, the mortality rate in patients of Child class A was compared with that in patients of Child class C, and the mortality rate in patients of Child class B was compared with that in patients of Child class C using Revman Software 5.0. Odd ratio (*OR*) with a 95% confidence interval (95% *CI*) was calculated. The heterogeneity across the studies were tested using an $I^2$ test and the difference was deemed significant when a score of $I^2>50\%$ or a $p$ value of $\leq 0.05$ was obtained. Begg's rank correlation method and Egger's weighted regression method were also used to statistically assess the publication bias ($P<0.05$ was considered to be representative of statistically significant publication bias).

As postoperative complicationsin the included studies were not classified by CTP, an analysis of the influences of various degrees of liver dysfunction on patient morbidity could not be conducted. Only the mean postoperative complication rates could be calculated and analyzed. The combined mean rates of mortality including hospital mortality and late mortality (dying after hospital discharge) and morbidity rates were analyzed using SPSS software version 17.00.

## Results

### *Search results and characteristics of included studies*

A total of 144 citations were recovered, however only 22 studies [1-4, 6, 8-24] (939 patients) and 20 reports [1-3, 6, 8-12, 14-24] (599 patients, from eight countries) included CTP classification and were therefore analyzed in this review as these studies represented the most suitable source to evaluate the association between liver dysfunction and the outcomes of cardiac surgery. The MELD score was used inanothertworeports [4, 13] (340 patients).

### *Mortality and morbidity*

Clinical outcomes after cardiac surgery in patients with liver dysfunction are summarized in **Tables 1** and **2**.

**Table 1.** Characteristics and mortality of included studies classified by CTP

| Study ID | Country | NO. of patient | Disease | Surgery | Age | Gender (M:F) | Patientin CTP classification (Number) | | | Death in CTP classification (Number) | | | | Follow-up |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | A | B | C | A | B | C | Overall | |
| Arif 2012 | Germany | 109 | Cirrhosis | CPB | 64.0 years | 82:27 | 74 | 29 | 6 | 14 | 12 | 2 | 28/109 | Hospital deaths |
| | | | | | | | | | | 55 | 27 | 6 | 81/109 | 5 years |
| Bacha 2004 | USA | 4 | Alagille's syndrome | Repair of ventricular septal defect and tricuspid regurgitation, Atrioventricular canal, subaortic stenosis, or supravalvular aortic stenosis | 10 week-2 year | - | 1 | 3 | 0 | 0 | 2 | 0 | 2/4 | 4 years |
| Bizouarn 1999 | France | 12 | Cirrhosis | CPB | 25-74 years | 8:4 | 10 | 2 | 0 | 2 | 1 | 0 | 3/12 | 26 months |
| Filsoufi 2007 | USA | 27 | Cirrhosis | CABG, valve replacement, Aortic procedure, Pericardiectomy | 58±10 years | 20:7 | 10 | 11 | 6 | 1 | 2 | 4 | 7/27 | 1052±654 days |
| Hayashida 2004 | Japan | 18 | Cirrhosis | CPB, CABG | 44-81 years | 11:7 | 10 | 7 | 1 | 0 | 2 | 1 | 3/18 | Hospital deaths |
| Kaplan 2002 | Turkey | 10 | Chronic Liver Disease | AVR, CABG, CPB, MVR | 57.1±6.85 years | 6:4 | 4 | 6 | 0 | 0 | 3 | 0 | 3/10 | 30.85±12.21 months |
| Klemperer 1998 | USA | 13 | Cirrhosis | CABG; valve operations | 53-79 years | 11:2 | 8 | 5 | 0 | 0 | 4 | 0 | 4/13 | Hospital deaths |
| Kur 2009 | Germany | 1 | Hepatitis C | Aortic valve and ascending aorta replacement | 43 years | 1:0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Hospital deaths |
| Lin 2005 | China | 18 | Cirrhosis | Valve replacement, CABG, CPB, mitral valvuloplasty | 35-76 years | 14:4 | 13 | 4 | 1 | 1 | 0 | 0 | 1/13 | Hospital deaths |
| | | | | | | | | | | 2 | 1 | 0 | 3/13 | 3-101 months |
| Lopez-Delgado 2013 | Spain | 58 | Cirrhosis | Valve replacement, CABG | 64.9±11.6 years | 40:18 | 34 | 21 | 3 | 0 | 5 | 2 | 7/34 | 120 months |
| Marrocco-Trischitta 2011 | Italy | 24 | Cirrhosis | Repair of infrarenal aortic aneurysm | 68±7 years | 23:1 | 22 | 2 | | 3 | 2 | | 5/24 | 30.7±22.1 months |
| Morimoto 2013 | Japan | 18 | Cirrhosis | CPB | 70.6 years | 14:4 | 0 | 14 | 4 | 0 | 3 | 0 | 3/18 | Hospital deaths |
| | | | | | | | 0 | 14 | 4 | 0 | 5 | 3 | 8/18 | 5.9 years (range 1.3-10.1) |
| Morisaki 2010 | Japan | 42 | Cirrhosis | CABG, valve surgery | 68.7±8.5 years | 31:11 | 30 | 12 | 0 | 0 | 4 | 0 | 4/42 | Hospital deaths |
| Murashita 2009 | Japan | 12 | Cirrhosis | CABG, valve surgery | 57-83 years | 5:7 | 6 | 6 | 0 | 3 | 1 | 0 | 4/12 | Hospital deaths |
| | | | | | | | | | | 4 | 1 | 0 | 5/12 | 23.9±13.5 months |
| Ota 2012 | USA | 61 | Liver transplant recipients | CABG, valve surgery, aortic root replacement | 61.5±8.2 years | 45:16 | 33 | 28 | 0 | 2 | 2 | 0 | 4/61 | Hospital deaths |
| | | | | | | | | | | 14 | 17 | 0 | 31/61 | 3.1±2.6 years |
| Sugimura 2012 | Japan | 13 | Cirrhosis | CABG, valve replacement, patch repair, pericardiectomy | 41-78 years | 10:3 | 7 | 5 | 1 | 0 | 1 | 0 | 1/13 | Hospital deaths |
| | | | | | | | | | | 0 | 2 | 0 | 2/13 | 2 years |
| Suman 2004 | USA | 44 | Cirrhosis | CPB | 15-74 years | 27:17 | 31 | 12 | 1 | 1 | 5 | 1 | 7/44 | 3 months |
| Thielmann 2010 | Germany | 57 | Cirrhosis | CPB | 62±10 years | 38:19 | 39 | 14 | 4 | 6 | 4 | 4 | 14/57 | 1528±256 days |
| Vanhuyse 2012 | France | 34 | Cirrhosis | Cardiac surgery with or without extracorporeal circulation | 64.8±12.8 years | 26:8 | 22 | 10 | 2 | 4 | 3 | 2 | 9/34 | Hospital deaths |
| An 2006 | China | 24 | Cirrhosis | AVR, MVR, TVR, CABG, pericardiectomy, Ascending aorta replacement | 53±13 years | 10:14 | 17 | 6 | 1 | 1 | 4 | 1 | 6/24 | Hospital deaths |

AVR: aortic valve replacement; CABG: coronary artery bypass graft; CPB: cardiopulmonary bypass; MVR: mitral valve replacement; TVR: tricuspid valve repair.

**Table 2.** Characteristicsof included studies classified by MELD

| Study ID | No. Of patient | Country | Disease | Surgery | Age | Gender (Male:Female) | Meld score cutoff | Patient in each group | Death in each group | Follow-up duration |
|---|---|---|---|---|---|---|---|---|---|---|
| Ailawadi 2009 | 168 | USA | Cirrhosis | Tricuspid valve surgery | 61±14 years | 96:72 | 15 | 37:131 | 7:8 | 30 day |
| Tsuda 2013 | 172 | Japan | Cirrhosis | Tricuspid valve surgery | 63.8±10.3 years | 66/106 | 7 | 54:114 | 8:2 | - |

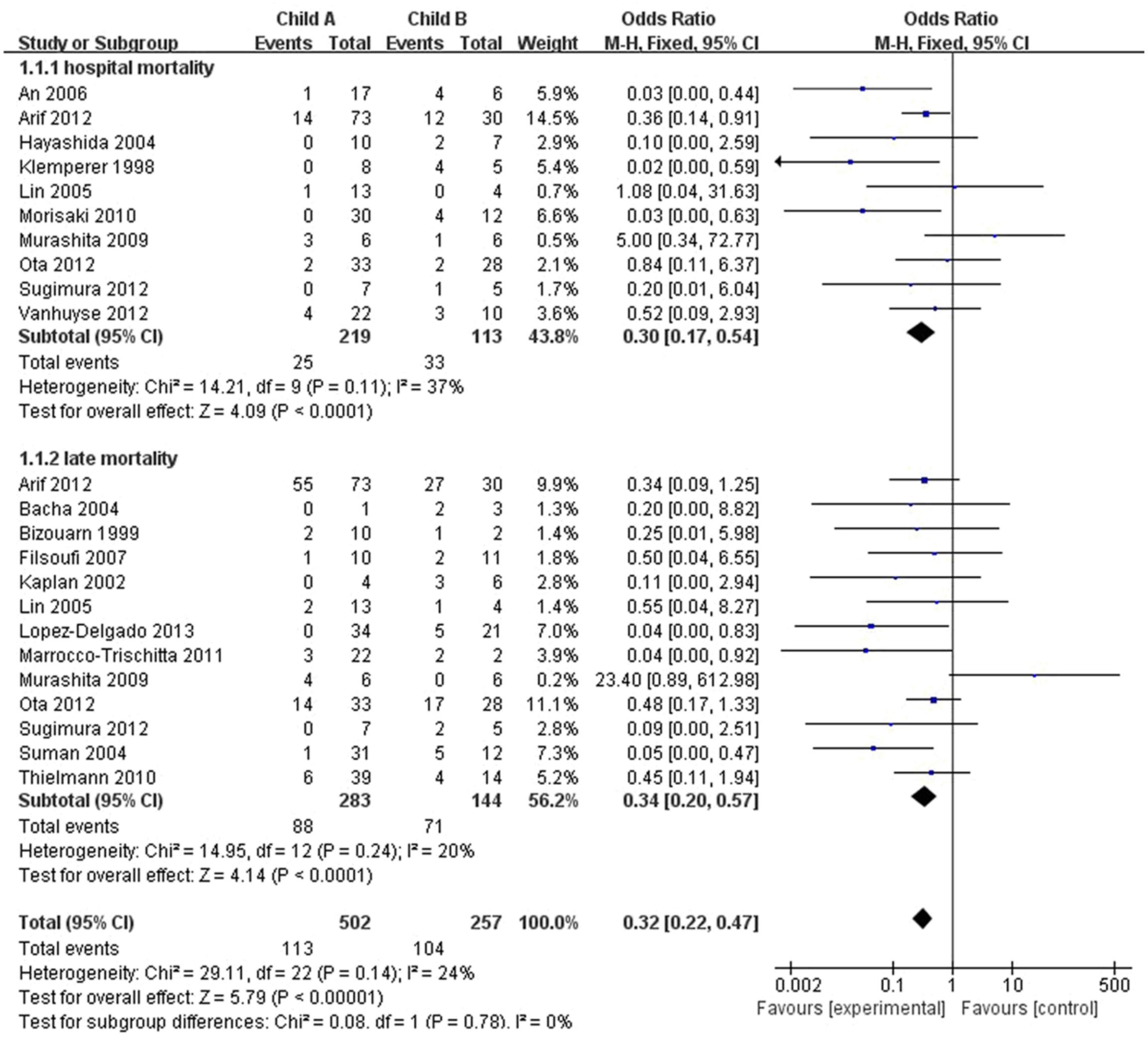


**Figure 1.** The mortality rate in patients of Child A versus the mortality rate in patients of Child B.

*Mortality:* In the 19 studies (the study conducted by Kur was not analyzed asitwas a case report and did not report any useful information in terms of mortality), there were 354 patients (61.57%) in Child class A, 205 in Child class B (35.65%) and 33 in Child class C (5.74%). The mean in-hospital mortality rates for patients in Child class A, B, and C were 8.92%, 31.38%, and 47.62% respectively and the mean late mortality rates were 20.58%, 43.58%, 56.48% for patients in Child class A, B and C respectively.

Compared topatients in Child class B, patients in Child class A had lower hospital mortality rates (*OR* 0.30, 95% *CI* 0.17 0.54, $I^2$=37%) and lower late mortality rates (*OR* 0.34, 95% *CI* 0.20 0.57, $I^2$=20%). A meta-analysis of all data showed that patients in Child class A have lower mortality rate (*OR* 0.32, 95% *CI* 0.22 0.47, $I^2$=24%) than patients in Child class B (**Figure 1**; **Table 3**).

Compared topatients in Child class C, patients in Child class A have lower hospital mortality

**Table 3.** Comparison of the mortality rates in patients of Child A,Child B and Child C

| Comparisons | subgroups | n | *OR* (95% CI) | | | Homogeneity | | | Publication Bias | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *OR* | *CI* | *P value* | *Q* | *Ph* | *I²* (%) | $P_{Begg}$ | $P_{Egger}$ |
| Child A | Hospital mortality | 10 | 0.37 | 0.17-0.54 | <0.01 | 14.21 | 0.11 | 37 | 0.441 | 0.316 |
| vs. | Late mortality | 13 | 0.34 | 0.20-0.57 | <0.01 | 14.95 | 0.24 | 20 | 0.741 | 0.825 |
| Child B | Total mortality | 23 | 0.32 | 0.22-0.47 | <0.01 | 29.11 | 0.14 | 24 | 0.411 | 0.325 |
| Child A | Hospital mortality | 5 | 0.16 | 0.05-0.49 | <0.01 | 4.03 | 0.40 | 1 | 0.348 | 0.561 |
| vs. | Late mortality | 6 | 0.07 | 0.02-0.27 | <0.01 | 4.85 | 0.43 | 0 | 0.829 | 0.891 |
| Child C | Total mortality | 11 | 0.10 | 0.05-0.24 | <0.01 | 10.11 | 0.43 | 1 | 0.145 | 0.158 |
| Child B | Hospital mortality | 7 | 0.79 | 0.29-2.12 | 0.63 | 3.77 | 0.71 | 0 | 0.348 | 0.216 |
| vs. | Late mortality | 7 | 0.20 | 0.07-0.56 | <0.01 | 2.88 | 0.82 | 0 | 0.151 | 0.231 |
| Child C | Total mortality | 14 | 0.39 | 0.20-0.77 | <0.01 | 9.90 | 0.70 | 0 | 0.521 | 0.821 |

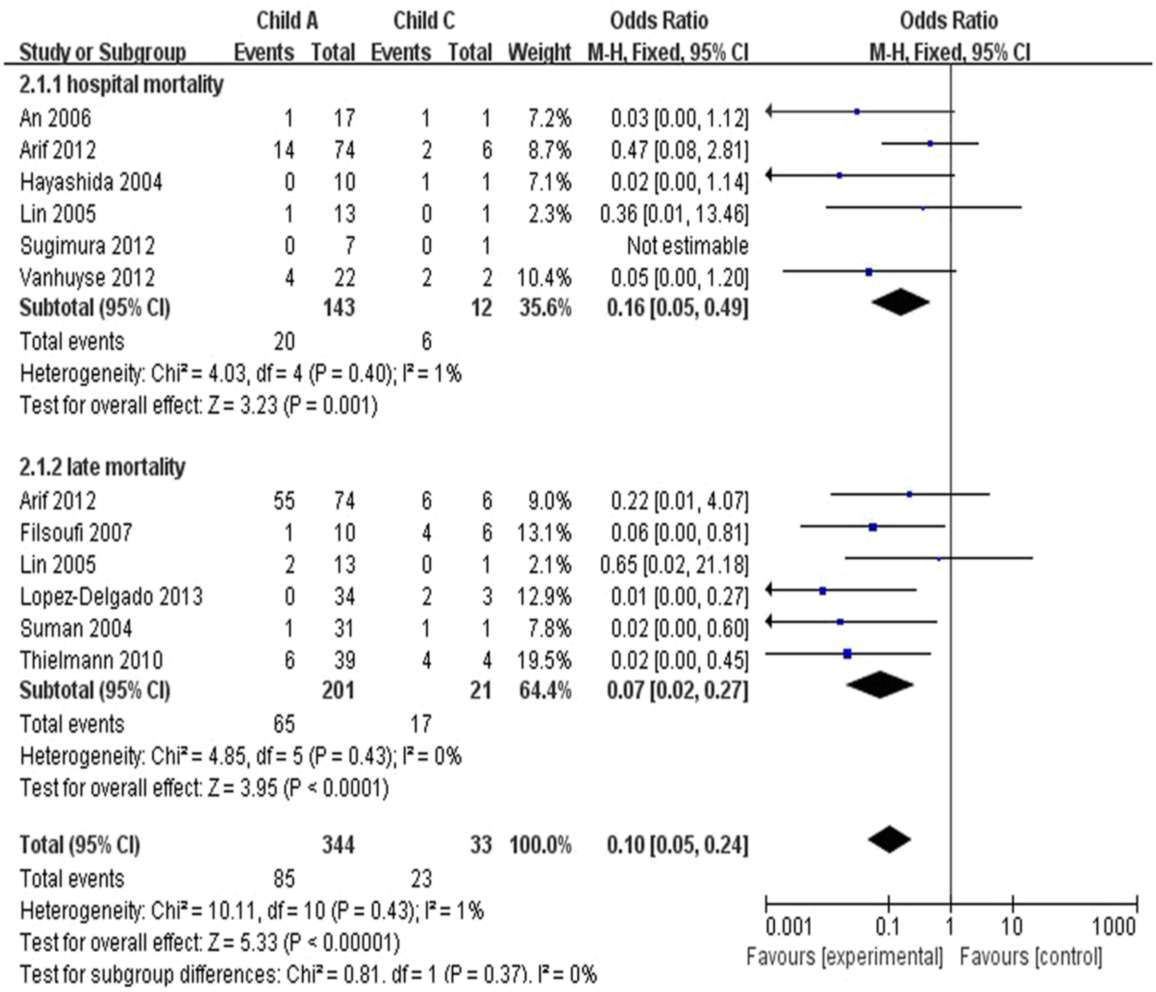


**Figure 2.** The mortality rate in patients of Child A versus the mortality rate in patients of Child C.

rate (*OR* 0.16, 95% *CI* 0.05 0.49, $I^2$=1%) and lower late mortality rate (*OR* 0.07, 95% *CI* 0.02 0.27, $I^2$=0%). A meta-analysis of all combined data showed that patients in Child class A have lower mortality rate (*OR* 0.10, 95% *CI* 0.05 0.24, $I^2$=1%) than patients in Child class C (**Figure 2**; **Table 3**).

Hospital mortality rate of Child class B patients was not significantly different to that of Child

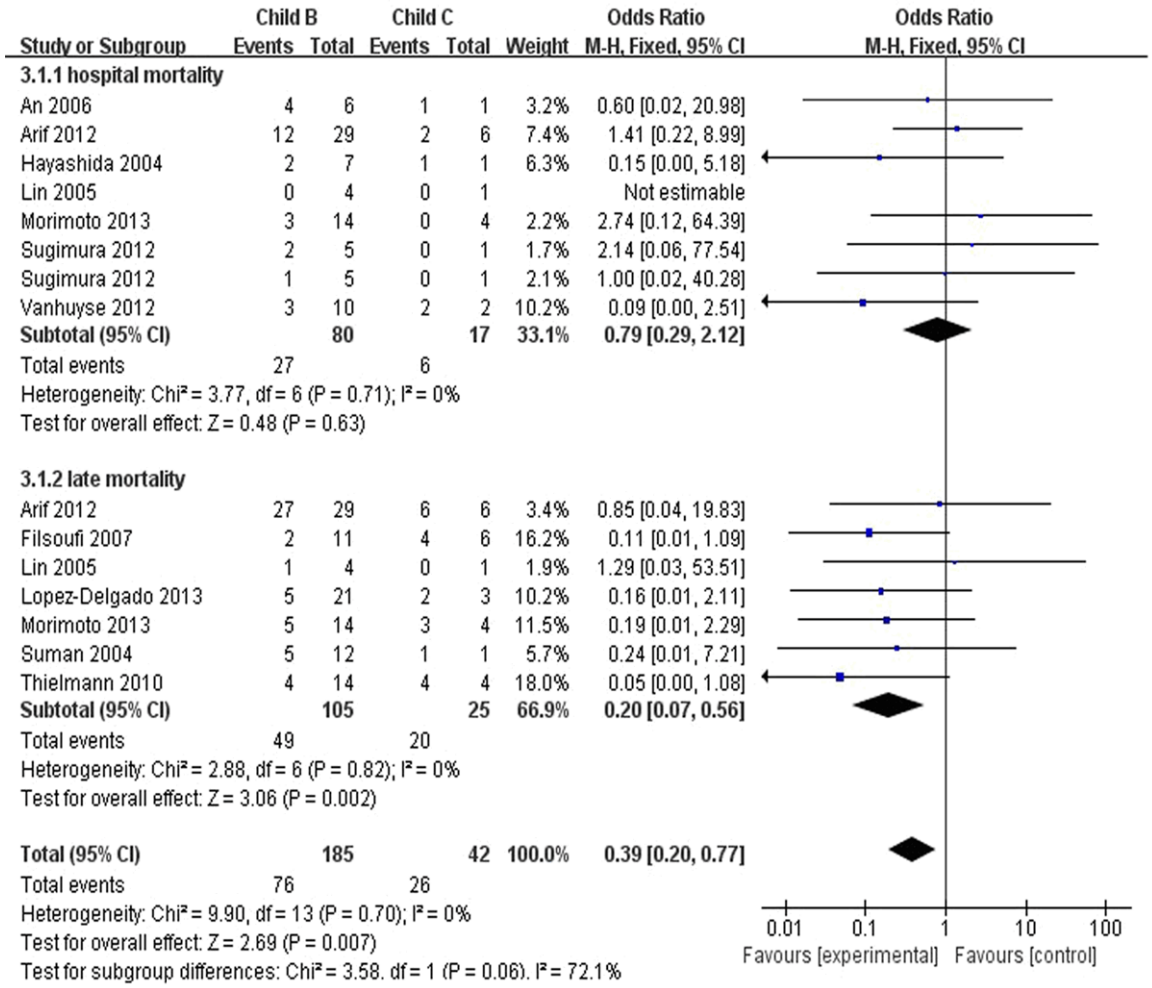


**Figure 3.** The mortality rate in patients of Child B versus the mortality rate in patients of Child C.

class C patients (*OR* 0.79, 95% *CI* 0.29 2.12, $I^2$=0%), however Child class B patients had a lower late mortality rate (*OR* 0.20, 95% *CI* 0.07 0.56, $I^2$=0%) compared to Child class C. A meta-analysis of combined data showed that Child class B patients have a lower mortality rate following cardiac surgery (*OR* 0.39, 95% *CI* 0.20 0.77, $I^2$=0%) compared with Child class C patients (**Figure 3**; **Table 3**).

One study included in this review reported significantly higher mortality rates in patients with a history of liver disease or MELD scores of 15 or greater (18.9% [7 of 37] vs 6.1% [8 of 131], *P*=0.024) compared to patients with no history of liver disease or MELD scores of less than 15 (168 patients that underwent tricuspid repair or replacement) [13]. One other study reported that hospital mortality rates increased in accordance with increased simplified MELD scores based on 172 patients that underwent tricuspid replacement or repair and that a higher simplified MELD score was an independent risk factor for increased in-hospital mortality [4].

*Morbidity:* A total of 22 studies [1-4, 6, 8-24] reported postoperative complications however the reported postoperative complications were not classified by CTP and could therefore not be analysed in this review in terms ofvarious degrees of liver dysfunction postoperative morbidity. Only the mean postoperative complication rates could be calculated and analyzed in this review.

The details of the morbidity if each study analyzed are presented in **Table 4**. The mean reexploration rate was 4.37%, the mean neurological complication rate 3.83%, the mean cardiovascular complication rate 2.67%, the mean

**Table 4.** Complications

| Study ID | NO. Of patient | Reexploration | Neurological | Cardiovascular | Pulmonary | Renal | Hepatic | Gastrointestinal | Sepsis + MOF | Bleeding + Cardiac Tamponade | Infectious |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Arif 2012 | 109 | 0 | 11 | 0 | 10 | 84 | 0 | 20 | 21 | 0 | 44 |
| Bacha 2004 | 4 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| Bizouarn 1999 | 12 | 0 | 0 | 2 | 1 | 0 | 4 | 0 | 1 | 2 | 3 |
| Filsoufi 2007 | 27 | 0 | 0 | 0 | 6 | 4 | 0 | 4 | 3 | 2 | 2 |
| Hayashida 2004 | 18 | 0 | 0 | 0 | 5 | 5 | 0 | 3 | 0 | 3 | 6 |
| Kaplan 2002 | 10 | 0 | 0 | 0 | 5 | 0 | 2 | 0 | 0 | 3 | 0 |
| Klemperer 1998 | 13 | 4 | 3 | 0 | 4 | 3 | 0 | 3 | 0 | 0 | 4 |
| Kur 2009 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lin 2005 | 18 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 4 | 4 |
| Lopez-Delgado 2013 | 58 | 11 | 0 | 22 | 0 | 5 | 0 | 0 | 0 | 1 | 0 |
| Marrocco-Trischitta 2011 | 24 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Morimoto 2013 | 18 | 0 | 0 | 0 | 2 | 1 | 3 | 0 | 0 | 5 | 0 |
| Morisaki 2010 | 42 | 0 | 1 | 2 | 7 | 6 | 2 | 2 | 0 | 4 | 3 |
| Murashita 2009 | 12 | 4 | 0 | 0 | 0 | 1 | 3 | 1 | 2 | 2 | 2 |
| Ota 2012 | 61 | 0 | 4 | 22 | 14 | 11 | 25 | 0 | 0 | 4 | 6 |
| Sugimura 2012 | 13 | 2 | 1 | 0 | 3 | 2 | 0 | 7 | 0 | 0 | 1 |
| Suman 2004 | 44 | 0 | 0 | 0 | 0 | 6 | 12 | 0 | 5 | 0 | 0 |
| Thielmann 2010 | 57 | 14 | 2 | 11 | 0 | 25 | 0 | 0 | 0 | 16 | 0 |
| Vanhuyse 2012 | 34 | 0 | 0 | 0 | 3 | 7 | 0 | 5 | 3 | 1 | 3 |
| An 2006 | 24 | 6 | 0 | 3 | 17 | 7 | 0 | 12 | 2 | 4 | 8 |
| Ailawadi 2009 | 168 | 0 | 4 | 0 | 49 | 32 | 0 | 8 | 7 | 0 | 0 |
| Tsuda 2013 | 172 | 0 | 9 | 53 | 26 | 8 | 0 | 10 | 9 | 0 | 0 |
| Total | 939 | 41 | 36 | 119 | 155 | 208 | 54 | 76 | 53 | 52 | 86 |
| Mean rate (%) | | 4.37 | 3.83 | 12.67 | 16.51 | 22.15 | 5.75 | 8.09 | 5.64 | 5.54 | 9.16 |

MOF: multiple organ failure.

pulmonary complication rate 16.51%, the mean renal complication rate was 22.15%, the mean hepatic complication rate was 5.75%, the mean gastrointestinal complication rate was 8.09%, the mean sepsis and multi organ failure complication rate was 5.64%, the bleeding and cardiac tamponade complication rate was 5.54% and the mean infectious complication rate was 9.16%.

*Heterogeneity*

Heterogeneity among all studies was calculated using the *Q* statistic ($Q$>0.10) and the $I^2$ statistic ($I$=0.0%). Heterogeneity was found in some groups, and the random effects model was used. An $I^2$ value for heterogeneity exceeding 80.0% was not found.

*Sensitivity analysis*

An influence analysis and a trim and filled analysis were both conducted to investigate the sensitivity of the pooled ORs and the test results. These analyses indicated that the pooled *OR*s were statistically robust.

*Publication bias*

This meta-analysis found no evidence for literature publication bias based on a *Begg's* funnel plot and *Egger's* test (**Table 3**).

**Discussion**

*Summary of finding*

As a result of the findings of this systematic review and meta-analysis, both in-hospital and late mortality rates, increase in accordance with increased CTP classification with the lowest mortality rates observed in Child class A patients. These findings are consistent with several studies and suggest that cardiac surgery can be safely conducted in Child class A patients [6, 11]. The highest in-hospital and late mortality rates were observed in Child class C patients, These findings were confirmed by previous studies reporting increased mortalities following cardiac intervention in Child class C patients [1-6]. For Child class C patients, that require cardiac surgery, it is suggested that they accept additional treatments to achieve optimal liver functions. For patients in Child class B, the in-hospital and late mortality rates were between those of the patients in Child class A, and C. Further longitudinal studies are required to determine if it is safe to conduct cardiac surgery Child class B patients Studies have shown that an MELD score may be of assistance as the MELD score relies entirely on objective parameters for its calculation without requiring subjective evaluations of the degree of ascites and encephalopathy [6]. In addition, studies have shown that the MELD score has an ample range of potential numeric values and mayfacilitate enhanced discrimination among patients with varying degrees of hepatic dysfunction [6, 25].

In this systematic review, the mean rate for the morbidity, and the morbidity rate following cardiac surgery varied from 3.83% (neurological complication) to 22.15% (renal complications). The primary three complications included renal complications (21.15%), pulmonary complications (16.51%) and cardiovascular complications (12.67%). As a result of this systematic review, it can be concluded that liver dysfunction could significantly affectsthe incidence of morbidity following cardiac surgery.

This review found that the mortality rate is lowest in Child class A patients and highest in Child class C patients, with a mean complication rate range from 3.83% to 22.15%. A reason for such high mortality and morbidity following cardiac surgery in patients suffering from liver disease includes increased vulnerability to bacterial infection. It has been reported that increased vulnerability to bacterial infection is related to the severity of liver dysfunction and may lead to abnormalities of the defense mechanisms [7]. Another reason may be coagulation disorders. As the liver plays an important role in the clotting process, coagulation disorders may be commonly linked with acute and chronic liver diseases. A final reason may be haemostatic disorders. Portal hypertension may lead to congestive splenomegaly with the trapping of platelets and thrombocytopenia, resulting in further postoperative bleeding [5, 6].

*Strength and limitations*

This study systematically reviewed the role of liver dysfunction as classified by CTP or MELD as a risk factor for increased mortality and morbidity in patients after cardiac surgery. A comprehensive and rigorous search of the Pubmedreference library and other sources including reference lists was conducted, a meta-analysis method was used to compare the mortality rate among patients classified as Child class A, B and C. The meta-analysis was not without its limitations. First, all studies included used CTP to classify liver function whilst only two studies used MELD scores. The study conducted by Thielmann et al [9] showed that MELD was the most superior predictive risk model in predicting in-hospital mortality and long-term survival. Second, the diseases of this review varied significantly. The majority of the reviewed studies focused on cirrhosis indicating that the conclusions of this review are only relevant to liver cirrhosis patients undergoing cardiac surgery. Thirdly, this systematic review only included several case-series or case reports, thus limiting the evidence level. Finally, a comparison between the morbidity rates, Child classes A, B and C was not conducted.

*Implications for future studies and practice*

Future cardiac surgical risk assessment models need to include liver function as a risk factor, as classified by CTP or MELD. In addition, comparative or controlled studies comparing cardiac surgical risk assessment systems with liver function and cardiac surgical risk assessment systems minus liver function need to be conducted. Furthermore, whilst MELD isthe most predictive risk model, and is clearly superior to CTP in predicting in-hospital mortality and long-term survival, few studies utilize MELD to classify liver function, indicating that in the future, MELD should be utilized to classify liver function as the superior cutoff point.

## Conclusion

Child class A patients have an acceptable mortality rate following cardiac surgery indicating that cardiac surgery can be safely carried out in these patients. Child class B patients however have a higher mortality rate following cardiac surgery and should seek further consultation and evaluation before surgery. The mortality in patients with Child class C is extremely high. These patients should be considered unacceptable for cardiovascular surgery. Patients with a higher MELD score havea significantly higher mortalityrate. Liver function must be viewed as an important risk factor for cardiovascular surgery, based on the strong association of this disease with mortality and morbidity.

## Disclosure of conflict of interest

None.

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