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Meta-analysis of postoperative myocardial injury as a predictor of mortality after living donor liver transplantation

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Abstract

Background: *The purpose of this study was to perform a systematic review and meta-analysis to investigate postoperative myocardial injury, as expressed by the postoperative concentration of high-sensitivity cardiac troponin I (hs-cTnI) as a predictor of mortality among living donor liver transplantation (LDLT) patients.*

Methods: *PubMed, Scopus, Embase and the Cochrane Library were searched through to September 1st 2022. The primary endpoint included in-hospital mortality. Secondary endpoints were 1-year mortality and re-transplantation occurrence. Estimates are expressed as risk ratios (RRs) and 95% confidence intervals (95% CIs). Heterogeneity was assessed with the I^2 test.*

Results: *During the search, 2 studies were found that fit the criteria and had a total of 527 patients. Pooled analysis showed that in-hospital mortality in patients with myocardial injury was 9.9%, compared to 5.0% for patients without myocardial injury (RR = 3.01; 95% CI: 0.97–9.36; p = 0.06). Mortality among 1-year follow-up was 5.0% vs. 2.4%, respectively (RR = 1.90; 95% CI: 0.41–8.81; p = 0.41).*

Conclusions: *In recipients with normal preoperative cTnI, myocardial injury LDLT may be associated with adverse clinical outcomes during a hospital stay, but the results were inconsistent at 1-year follow-up. Although routine follow-up of postoperative hs-cTnI, even in patients with normal preoperative levels, might still help predict the clinical outcome of LDLT. In future large and more representative studies are needed to establish the potential role of cTnI in perioperative cardiac risk stratification.* (Cardiol J)

Key words: myocardial injury, mortality, living donor, liver transplantation, meta-analysis, systematic review

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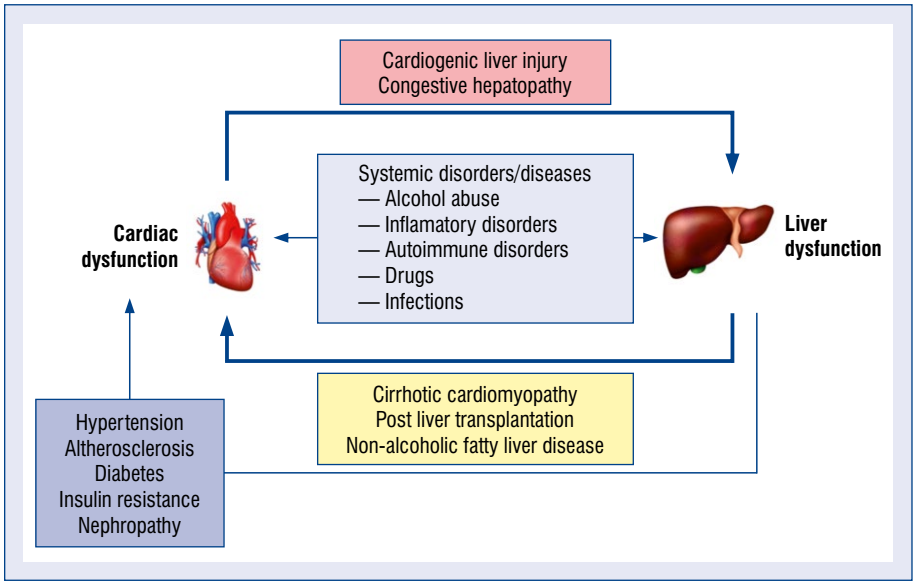

Figure 1. Factors affecting the correlation between the heart and the liver.

Introduction

Cardiovascular morbidity and mortality in patients undergoing non-cardiac surgery (NCS) are determined by patient-related risk and the type of surgery or procedure, including the circumstances under which they occur [1–3]. Surgery-related risk (only the surgical intervention risk, without considering the patient's comorbidities) is determined by the surgery type and duration, as well as urgency of the procedure. The surgical risk estimate is the sum of the 30-day risk of cardiovascular (CV) death, myocardial infarction (MI), and stroke [4]. Liver transplantation (LTx) is associated with to high surgical risk (> 5%). Patient-related risk is determined by the patient's age, the presence of CV risk factors or established CV disease and other comorbidities. The perioperative risk for cardiac complications depends on the presence and extent of cardiac disease [5]. Perioperative myocardial injury has multiple underlying etiologies [6, 7] and is categorized into type 1 MI, caused by plaque rupture, and type 2 MI, resulting from myocardial ischemia secondary to a supply-demand mismatch, as occurs in hypotension or anemia.

Living donor liver transplantation (LDLT) is increasingly embraced as an essential strategy to address the shortage of donor's livers from recently deceased patients. LDLT can be associated with myocardial injury, the pathophysiology of which may be partly related to ischemia or reperfusion injury rather than an atherosclerotic burden. Ischemia and reperfusion injury are a well-established underlying cause of damage in transplant recipient's organs, with cold ischemia time considered a significant risk factor of postreperfusion syndrome in patients with liver transplantation (Fig. 1) [8, 9].

High-sensitivity cardiac troponin T/I (hs--cTnT/I) quantifies myocardial injury [10–14]. Several prospective studies have shown that pretransplant hs-cTnT/I has a high predictive value for perioperative cardiac complications, including CV death, cardiac arrest, acute heart failure, and tachyarrhythmias, in patients after LTx [15–20].

The most recent guidelines for NCS from the European Society of Cardiology recommend measuring hs-cTnT/I to detect myocardial injury before intermediate- and high-risk NCS and at 24 and 48 hours afterwards. Since LTx is a high surgical risk, pre-and post-operative hs-Tn measurements are indicated [21]. Since the utility of hs-Tn measurement in LDLT is not well confirmed, our purpose was to perform a systematic review and meta-analysis to investigate a postoperative myocardial injury, as expressed by the postoperative concentration of hs-cTI as a predictor of mortality among LDLT patients.

Methods

The study was designed, conducted, and reported according to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [22].

Search strategy and selection criteria

A comprehensive literature search was conducted through the electronic databases of PubMed, Scopus, Embase and Cochrane Library from inception to September 1st 2022. Only English articles published in peer-reviewed journals were considered. The search keywords were as follows: "Troponin I" OR "Cardiac troponin I" OR "cTnI" OR "myocardial injury" OR "coronary event" AND "living donation" OR "living donor" AND "liver" AND "transplantation". Additionally, reference lists of related original articles, review articles and meta-analyses were further screened for potentially eligible publications using a manual approach by 2 reviewers (M.P. and L.S.). Any disagreement was resolved by discussion with a third reviewer (L.S.). Initial search results were merged and imported into the reference management software EndNote® X7 (Philadelphia, PA, USA).

Studies that meet all of the following criteria were included in the systematic review and meta-analysis: (1) study of the troponin I value among LDLT; (2) prospective, cross-sectional, retrospective as well as randomized controlled trials; (3) articles published in English.

Studies with any of the following criteria were excluded: (1) editorials, conference abstracts; (2) articles not written in English; (3) no sufficient data.

Data extraction

Two researchers (K.J. and M.P.) each did their own data collection using an electronic tool that had already been set up. Another investigator (L.S.) was in charge of settling any disputes. Any disagreement was resolved by another investigator (L.S.). All available information, including article details (title, first author, year of publication, country, number of patients), participant characteristics (age, sex), as well as mortality outcomes, were extracted from the literature search.

Primary outcome

The primary outcome was survival to hospital discharge, with secondary outcomes of 1-year follow-up and re-transplantation rates among patients with myocardial injury versus those without a myocardial injury. A myocardial injury was defined as an elevated troponin. Elevated troponin was defined as exceeding the manufacturer's 99th percentile upper reference level in a healthy population for the reported assay.

Quality assessment

A methodological quality assessment was performed according to the Newcastle–Ottawa Quality Scale (NOS). NOS measures the quality of a study based on three aspects: selection, comparability, and exposure. The maximum scores for these three aspects were 4, 2 and 3 stars, respectively. Studies with NOS scores ≥ 7 were considered high-quality studies [23].

Statistical analysis

The authors used the STATA 14 software (StataCorp LLC, College Station, TX, USA) and Review Manager, Version 5.4 (The Nordic Cochrane Center, The Cochrane Collaboration, 2014). Continuous data were presented as forest plots with the mean difference (MD) and 95% confidence intervals (CIs). For parameters where the data were reported as median with interquartile range, we use the Hozo formula [24] to estimate means and standard deviations. Dichotomous data we expressed as odds ratios or risk ratios (RRs), with 95% CI. Statistical heterogeneity across studies was assessed using the I^2 statistic. An I^2 value was grouped into four intervals: 0–25%, 26–50%, 51–75%, and > 75%, and represented insignificant, low, moderate, and high heterogeneity, respectively [25]. The RR or MD was pooled using a fixed-effects model to manage heterogeneity if insignificant (I^2 < 50%); otherwise, a random-effects model was applied. A p-value of < 0.05 was considered significant. Egger's test and funnel plots were used to assess potential bias. We performed funnel plot tests for asymmetry to investigate potential publication bias if there were more than ten trials in a single meta-analysis.

Results

Literature search, study selection and study characteristics

The process of study identification and selection is shown in the PRISMA flow chart (Fig. 2). Based on the initial search strategy, 184 studies were identified from the online databases. After deleting duplicate records, a total of 119 records were retained. Then based on the titles and abstracts evaluation — 103 articles were excluded. After the full-text screening, only 2 articles published between 2018 and 2019 were assessed for eligibility in the meta-analysis [26, 27]. One of the 2 articles used a contemporary troponin

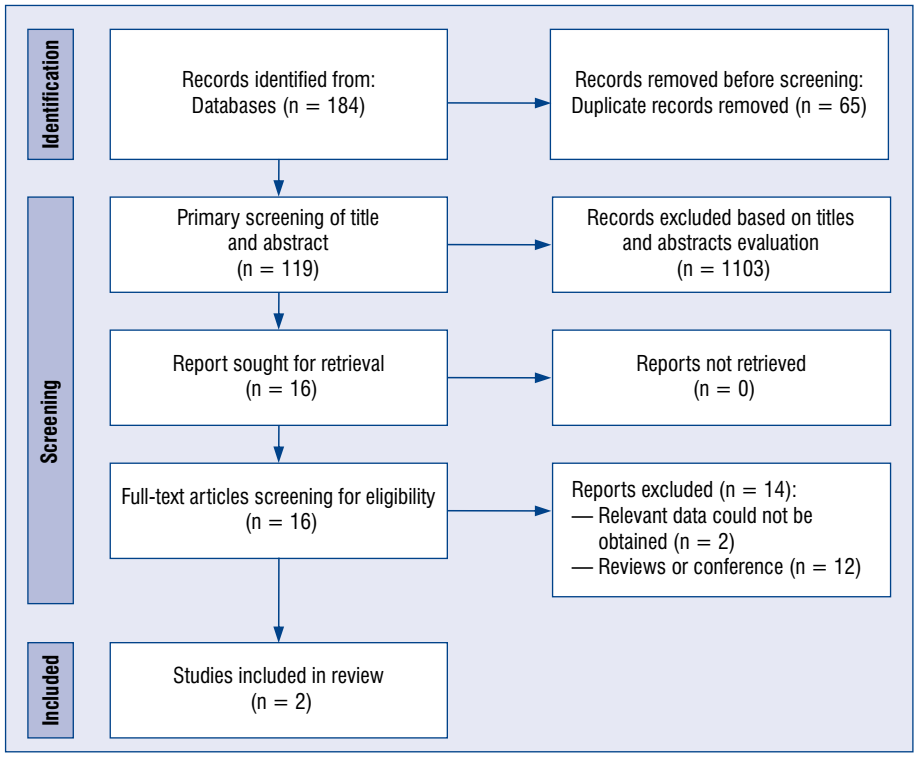

Figure 2. Flow chart of the study selection process.

platform [27]. However, they did not report the assay manufacturer, and the other used the Advara Centaur high-sensitivity troponin assay (Siemen's Healthineers).

The mean age of patients with myocardial injury was 55.0 ± 12.1 years compared to 55.3 ± ± 9.4 years for patients without myocardial injury (MD = 0.52; 95% CI: –2.52 to 3.55; p = 0.74), and the sample size ranged from 214 to 313 patients. Table 1 demonstrates the characteristics of the included trials. All trials were single-country and conducted in Turkey [26] and Korea [27]. Overall, the risk of bias for the included trials was low (Table 1).

Meta-analysis outcomes

Two studies reported in-hospital mortality among patients with and without MI. Pooled analysis showed that in-hospital mortality in patients with myocardial injury was 9.9%, compared to 5.0% for patients without myocardial injury (RR = 3.01; 95% CI: 0.97–9.36; p = 0.06).

Both studies reported 1-year mortality. Pooled analysis of mortality among 1-year follow-up was 5.0% vs. 2.4%, respectively (RR = 1.90; 95% CI: 0.41–8.81; p = 0.41).

Only the study performed by Park et al. [27] reported the occurrence of re-transplantation occurrence. Dichotomized into groups with and without myocardial injury found reimplantation rates of 1.9% vs. 0.6%, respectively, during in-hospital follow-up (RR = 2.91; 95% CI: 0.31–27.63; p = 0.35), and 1.9% vs. 1.3%, respectively after 1-year follow-up (RR = 1.45; 95% CI: 0.25–8.58; p = 0.68).

Discussion

Overall, we found only 2 retrospective studies, out of 184 records, concerning perioperative myocardial injury in LDLT. Both studies aimed to evaluate the effect of myocardial injury after LDLT on 30-day in-hospital and 1-year mortality [27]. In both studies, myocardial injury included an ischemic and nonischemic etiology and was defined as an elevation of cTnI above upper reference limit according to the 99th percentile. There were similar criteria of exclusion from the studies, which consisted of all patients without postoperative troponin levels and normal preoperative troponin levels. However, there were variations in the timing of obtaining troponin measurements. In the study of Park et al. [27], routine postoperative hs-cTnI was done immediately after arriving at the intensive care unit. In the Canbolat et al. [26] study, cTnI

Table 1. Characteristics of included trials.

Study	Country	Study design	99th %	Myocardial injury event group			Non-myocardial injury event group			NOS score
				Patients (n)	Mean age (SD)	Sex, male (%)	Patients (n)	Mean age (SD)	Sex, male (%)	
Conbolat et al., 2019 [26]	Turkey	RC	0.04 ng/mL	123	53 (16)	85 (69.1)	91	56 (12)	72 (79.1)	8
Park et al. 2018 [27]	Korea	RC	0.04 ng/mL	159	55.9 (8.7)	121 (76.1)	154	55.3 (8.8)	128 (83.1)	9

NOS — Newcastle Ottawa Score; RC — retrospective cohort; SD — standard deviation

was evaluated every 24 hours for 3 days. The peak value was included in the study.

Although in the Canbolat et al. [26] study, myocardial injury, as manifest by an elevated contemporary troponin, was common (57.4%) after LDLT and more frequent than after other high-risk surgical operations, it was not associated with 30-day in-hospital or 1-year mortality. This may have been a function of using a contemporary troponin assay, and different results may have occurred by using a highly sensitive troponin. The findings of Park et al. [27] support this consideration. They reported that in liver recipients with normal preoperative hs-cTnI, myocardial injury after LDLT may be associated with clinical outcomes during the hospital stay. Still, the results were inconsistent at the 1-year follow-up. In this study, the incidence of all-cause death or graft failure during hospitalization was significantly higher in recipients with myocardial injury (1.9% vs. 7.6%; HR = 4.15; 95% CI: 1.01–17.14; p = 0.049). The same result was also shown in a propensity-matched population (0.9% vs. 9.0%; HR: 9.08; 95% CI: 1.16–71.01; p = 0.04). In recipients with normal preoperative hs-cTnI, the elevation of hs-cTnI during LDLT was present in about half of recipients (50.5%) [26]. Our pooled analysis showed that in-hospital mortality in patients with myocardial injury was 9.9%, compared to 5.0% for patients without myocardial injury (RR = 3.01; 95% CI: 0.97–9.36; p = 0.06). Pooled analysis of mortality at 1-year follow-up was 5.0% vs. 2.4%, respectively (RR = 1.90; 95% CI: 0.41–8.81; p = 0.41).

In a commentary on Park et al. [27] study, Mandell and Kay [28] noticed that, although the findings were interesting, it was unclear how the information presented in their paper would improve the clinical care of LDLT patients. They pointed out that there are no reference values for unusual populations, e.g., pre-and postoperative liver transplant patients. In addition, the reference ranges used for the diagnosis of MI may not have equal predictive value for overall early mortality or graft loss. However, they appreciated the results of the Park et al. [27] study as opening the way for taking the next step in clinical care [28].

Prior studies have reported that elevated hs-cTn is an independent predictor of major adverse cardiac events, that the postoperative hs-cTn levels peak during the first 3 days after surgery, and that they are significantly linked to 30-day mortality in populations of patients having both cardiac and noncardiac surgery [29]. In addition, preoperative cardiac troponin levels were associ-

ated with all-cause mortality after LTx [30, 31]. However, limited data have focused on myocardial injury related to LDLT.

Ideally, the hs-cTnI assay could be used as a risk stratification tool as it is an inexpensive, rapid blood test that is widely available and routinely performed at many institutions. Using a clearly defined cut-off point in a clinical setting, e.g., the 99th percentile reference limit, would obviate the difficulties of applying complex scoring systems to particular patients and prevent the potential for subjective interpretation of clinical parameters. Included as part of the preoperative evaluation, greater care may be focused on before the transplantation procedure in those with potentially unfavorable outcomes from underlying cardiac and non-cardiac illnesses.

Limitations of the study

Because of limitations in prior publications, only 2 papers were available for our meta-analysis, so the number of individual patients is relatively small. Furthermore, both studies were retrospective and used different troponin assays (a highly sensitive test and a non-highly-sensitive test). New-generation cardiac troponin assays have widened the predictive value of non-ischemic myocardial injury in many conditions, e.g., congestive heart failure. Thus, using a lower sensitivity assay in the Conbolat et al. [26] study may have resulted in an underestimation of the predictive capability of troponin measurement.

Conclusions

In recipients with normal preoperative cTnI, myocardial injury LDLT may be associated with adverse clinical outcomes during a hospital stay, but the results were inconsistent at 1-year follow-up. Although routine follow-up of postoperative hs-cTnI, even in patients with normal preoperative levels, might still help predict the clinical outcome of LDLT. In future large and more representative studies are needed to establish the potential role of cTnI in perioperative cardiac risk stratification.

Conflict of interest: None declared

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