Transplantation Reviews 35 (2021) 100633

Contents lists available at ScienceDirect

Transplantation Reviews

journal homepage: www.elsevier.com/locate/trre

Review article

A comparison between combined liver kidney transplants to liver transplants alone: A systematic review and meta-analysis

Sarah Bouari [a], Elsaline Rijkse [a], Herold J. Metselaar [b], Martijn W.F. van den Hoogen [c], Jan N. M. IJzermans [a], Jeroen de Jonge [a], Wojciech G. Polak [a], Robert C. Minnee [a,*]

[a] Department of Surgery, Division of HPB & Transplant Surgery, Erasmus MC University Transplant Institute, Rotterdam, the Netherlands
[b] Department of Gastroenterology and Hepatology, Erasmus MC University Transplant Institute, Rotterdam, the Netherlands
[c] Department of Internal Medicine, Section of Nephrology and Transplantation, Erasmus MC University Transplant Institute, Rotterdam, the Netherlands

ARTICLE INFO

Keywords:
Combined liver kidney transplantation
Liver transplantation
Renal dysfunction
Allocation policy

ABSTRACT

Background: Since the introduction of the Model for End-stage Liver disease criteria in 2002, more combined liver kidney transplants are performed. Until 2017, no standard allocation policy for combined liver kidney transplant (CLKT) was available and each transplant center decided eligibility for CLKT or liver transplant alone (LTA) on a case-by-case basis. The aim of this systematic review was to compare the clinical outcomes of CLKT compared to LTA in patients with renal dysfunction.
Methods: Databases were systematically searched for studies published between January 2010 and March 2021. Outcomes were expressed as risk ratios and pooled with a random-effects model. The primary outcome was patient survival.
Results: Four studies were included. No differences were observed for mortality risk at 1 year (risk ratio (RR) 1.03 [confidence interval (CI) 0.97–1.09], 3 years (RR 1.06 [CI 0.99–1.13]) and 5 years (RR 1.08 [CI 0.98–1.19]). The risk of graft loss was similar in the first year (RR 1.10 [CI 0.93–1.30], while 3-year risk of graft loss was significantly lower in CLKT patients (RR 1.15 [CI 1.08–1.24]).
Conclusions: CLKT has similar short-term graft and patient survival as LTA in patients with renal dysfunction. More data is needed to decide from which KDIGO stage patients benefit the most from CLKT.

1. Introduction

Pretransplant renal dysfunction is an important determinant of morbidity and mortality following liver transplantation [1]. Combined liver kidney transplantation (CLKT) has been employed as a treatment modality for individuals with end-stage liver disease and renal dysfunction abrogating this risk [2–4]. Since the introduction of the Model for End-stage Liver Disease (MELD) criteria in 2002, there has been an increase in CLKT especially in the United states of America (USA), as patients with renal failure have a higher MELD score [5–7]. The indications for CLKT can be divided in three categories: I) end-stage liver disease with chronic kidney disease (CKD), II) end-stage liver disease with acute kidney injury (AKI), III) metabolic disorders [5]. CKLT is straightforward for patients with both end-stage liver and renal disease necessitating renal replacement therapy (RRT). However, it is less well-defined for patients with mild to moderate renal dysfunction and those with causes of acute renal failure, including hepato-renal syndrome, due to the potential reversibility of renal failure after LTA. Definitions of renal dysfunction differ, with some stating that it should be defined according to a certain KDIGO stage and serum creatinine, while others state that renal dysfunction cannot be based on a laboratory value as complications of kidney disease can occur even at a relatively low creatinine level and need for RRT is not determined by glomerular filtration rate (GFR) alone.

Concerns about the lack of clear rules for CLKT allocation have increased alongside the growing number of CLKT transplants. Until 2017, no standard allocation policy for CLKT was available in the USA and each transplant center decided eligibility on a case-by-case basis

Abbreviations: AKI, Acute Kidney Injury; CKD, Chronic Kidney Disease; CLKT, Combined Liver Kidney Transplant; GFR, Glomerular Filtration Rate; LTA, Liver Transplant Alone; MELD, Model for End-stage Liver Disease; NOS, Newcastle-Ottawa Scale; PNF, Primary non-function; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis; RR, Risk ratio; RRT, Renal Replacement Therapy; UNOS, United Network for Organ Sharing.

* Corresponding author at: Department of Surgery, Division of HPB & Transplant Surgery, Doctor Molewaterplein 40, 3015 GD Rotterdam, the Netherlands.
E-mail address: r.minnee@erasmusmc.nl (R.C. Minnee).

https://doi.org/10.1016/j.trre.2021.100633

Available online 1 June 2021

[6,8]. Since 2017, the United Network for Organ Sharing (UNOS) has implemented an allocation policy for CLKT. This policy defines medical eligibility criteria for CLKT and provides a safety-net mechanism by assigning priority for renal allograft allocation to LTA recipients with end-stage renal disease within 1 year after liver transplantation [9,10].

The outcomes of CLKT in comparison to LTA in patients with renal dysfunction are still unknown.

Therefore, to ensure optimal use of donor organs, we performed a systematic review and meta-analysis concerning outcomes after CLKT in comparison to recipients with renal dysfunction who underwent LTA.

2. Materials and methods

The article was written according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [11].

2.1. Search strategy

A literature search was performed in the Embase, Ovid Medline, Cochrane Central and Google Scholar databases. Searches were conducted using MeSH and EMTREE keywords. Detailed search strategies are included in the Supplemental Digital Content, Table 1. The final literature search was performed on March 18th, 2021.

2.2. Study selection

We used predefined exclusion criteria: studies describing pediatric CKLT or LTA, non-English articles, articles published before 2010, specific types of articles (e.g. conference abstracts, letters to the editor, replies, editorials, case reports, guidelines and reviews). Titles and abstracts of retrieved articles were independently evaluated by two reviewers (S.B. and E.R.). The remaining studies were assessed for relevance by evaluation of full-text articles. Disagreements were solved by consensus or by a third reviewer (R.C.M.). Studies were included if they compared clinical outcomes of CLKT with LTA in recipients with renal dysfunction. If multiple articles used the same database, the study with the largest number of patients receiving CLKT was selected and the other studies were excluded to avoid duplicate cases.

2.3. Data collection and extraction

The following outcomes were considered as of clinical relevance: patient survival, liver graft survival, MELD score, indication for liver transplantation, ethnicity, diabetes mellitus, liver rejection, reoperation rate, primary non-function, delayed graft function, subsequent kidney transplantation, and post-operative biliary or vascular problems. If survival outcomes were presented with Kaplan-Meier curves, DataThief III software was used to deduce the events from the survival curves.

2.4. Quality of evidence assessment

Two authors (S.B. and E.R.) independently assessed the risk of bias in all eligible studies using the adapted Newcastle-Ottawa Scale (NOS) for either case-control studies or cohort studies, depending on study design [12].

2.5. Statistical analysis

Baseline characteristics were constructed to assess possible confounding between the CLKT and LTA group. For continuous variables, group means weighed for number of included patients was reported with pooled standard error, if the included study presented the continuous data as mean and standard deviation. If medians were reported instead of group means, means and standard deviation were calculated using estimation calculations [13]. Normality of the means was assumed because of the sample size, according to the central limit theorem. Therefore, baseline characteristics were compared with the unpaired *t*-test in case of continuous variables and with the chi-square test for categorical variables using MedCalc software (version 16.2). Review Manager 5.3 was used for meta-analysis. Because of the study design, we anticipated heterogeneity between the included studies and therefore, we used a random effects model. Potential statistical heterogeneity between studies was estimated by the I^2 statistic which was defined as low (0–25%), moderate (25–75%) or high (>75%) and by inspecting the funnel plots. The outcomes were presented as risk ratios (RR) with corresponding 95% confidence intervals (CI) and analyzed using the Mantel-Haenszel method. A *P* value below 0.05 was considered statistically significant.

3. Results

The initial literature search identified 3165 potentially relevant studies across all databases. Four studies met our inclusion criteria from which data was extracted for meta-analysis (see Supplemental Fig. 1) [14–17]. One article using the UNOS database was included for the analyses on patient survival [14]. As this article did not mention liver graft survival, the article with the second largest number of patients receiving CLKT using the UNOS database was selected for these analyses [15]. Four articles were excluded as they did not compare CLKT to LTA in patients with renal dysfunction [18–21]. Characteristics of the included studies are summarized in Table 1.

3.1. Baseline characteristics

Baseline characteristics of patients in the included studies are presented in Table 2. Patients receiving CLKT were significantly older, and significantly more often male (65.1% and 62.3%, $p < 0.001$). BMI was

Table 1
Studies included for the comparison of CLKT to LTA.

Study	Design	LTA	CLKT	Matching	Underlying disease	Outcomes	NOS score
Jay, 2020 USA	Retrospective Observational	11501[a]	6774	No matching	LTA with renal dysfunction (serum creatinine >2.5 mg/dL or RRT at time of transplant)	1	9/9
Li, 2016 China	Retrospective Observational	25	21	No matching	LTA in patients with hepatitis B with renal dysfunction (any)	1, 3, 4	9/9
Pita, 2019 USA	Retrospective Observational	162[b]	3395	No matching	LTA with renal dysfunction (on RRT at time of transplant)	2	9/9
Tinti, 2019 UK	Retrospective Observational	741	117	No Matching	LTA with renal dysfunction (from stage 3b)	1, 2	9/9

Outcomes: 1. Patient survival, 2. Liver graft survival, 3. Liver rejection, 4. Incidence of primary non-function of the liver graft.
[a] Patients who received a LTA without subsequent kidney transplantation.

[b] Patients who received a LTA while waitlisted for CLKT.

Table 2
characteristics of included studies.

Characteristics	Studies	LTA	Total patients	CLKT	Total patients	*P*-value
Recipient age, mean (SD)	3[1,2,3]	53.1 (11.1)	12,267	54.9 (10.0)	6912	<0.001
Male sex, n (%)	4[1,2,3,4]	7770 (62.3)	12,465	6718 (65.1)	10,326	<0.001
Diabetes mellitus [a], n (%)	3[2,3,4]	2905 (24.2)	12,017	4178 (40.7)	10,255	<0.001
MELD score, mean (SD)	3[1,2,3]	36.3 (7.0)	12,267	29.9 (8.0)	6912	<0.001
Pre-transplant dialysis, n (%)	4[1,2,3,4]	7010 (56.2)	12,465	7539 (73.0)	10,326	<0.001
Serum creatinine umol/L[b], mean (SD)	2[1,2]	172 (44)	461	322 (185)	66	<0.001
Ethnicity	3[2,3,4]		12,440		10,305	<0.001
Caucasian, n (%)		8731 (70.2)		6451 (62.6)		
Non-Caucasian, n (%)		3709 (29.8)		3854 (37.4)		
Recipient BMI, mean (SD)	2[2,3]	28.8 (6.0)	12,242	27.0 (6.0)	6891	<0.001
Indication for liver transplant	1[2]		696		91	
Alcoholic cirrhosis, n (%)		185 (26.6)		15 (16.5)		0.038
HCV cirrhosis, n (%)		80 (11.5)		9 (9.9)		0.651
PBC, n (%)		95 (13.6)		2 (2.2)		0.002
PSC, n (%)		58 (8.3)		1 (1.1)		0.014
NASH, n (%)		28 (4.0)		0 (0.0)		0.052
HBV cirrhosis, n (%)		11 (1.6)		1 (1.1)		0.716
Auto-immune, n (%)		22 (3.2)		1 (1.1)		0.266
Re-OLT, n (%)		92 (13.2)		12 (13.2)		1.000
Polycystic, n (%)		10 (1.4)		26 (28.6)		<0.001
Other, n (%)		125 (18.0)		36 (39.6)		<0.001

Li[1], Tinti[2], Jay[3], Pita[4].
[a] Missing values in Tinti et al. are excluded.

[b] Excluding dialysis patients in the study from Tinti et al.

lower in patients receiving CLKT compared to LTA (27.0 versus 28.8, $p < 0.001$). Patients receiving CLKT were more often non-Caucasian (37.4% versus 29.8%, $p < 0.001$).

The MELD score was higher in the LTA group compared to the CLKT (36.3 and 29.9, $p < 0.001$). Both serum creatinine and percentage receiving dialysis before transplantation were higher in the CLKT group (322 versus 172 umol/L, $p < 0.001$; and 73.0% versus 56.2%, $p < 0.001$).

Renal dysfunction was defined differently in the included articles and did not only include patients requiring renal replacement therapy but also patients with stage 3–4 chronic kidney disease. One article, Tinti et al. [17] made a subgroup analysis based on kidney function. We have pooled these subgroups to perform a comparable analysis to the other studies.

Pita et al. [15] used two control groups: the first included patients who were waitlisted for CLKT but received LTA, the second included patients that received LTA and were not waitlisted for CLKT. The second group was not included in our analyses. In total these were 198 patients (3.6%) who received a LTA despite being waitlisted for CLKT, versus 5359 patients (96.4%) who received a LTA and were not waitlisted for CLKT. Table 1 describes the definitions of renal dysfunction used per study.

3.2. Patient survival

There was no significant difference in mortality risk between CLKT and LTA recipients after 1 year with a pooled RR of 1.03 (95% CI 0.97–1.09, $p = 0.31$) (Fig. 1A). The 3-year mortality risk was not statistically significant with a pooled RR of 1.06 (95% CI 0.99–1.13, $p = 0.11$) (Fig. 1B). The 5-year mortality risk also did not differ significantly with a pooled RR of 1.08 (95% CI 0.98–1.19, p = 0.11) (Fig. 1C). Statistical heterogeneity was moderate for the outcomes after 1, 3 and 5 years (I^2 57%, 57% and 68% respectively).

3.3. Liver graft survival

Two studies presented data on graft survival rates at 1 and 3 years [15,22]. The risk of liver graft loss was not significantly different at 1 year (RR 1.10, 95% CI 0.93–1.30, $p = 0.26$) (Fig. 2A). The risk of liver graft loss at 3 years was increased in LTA recipients (RR 1.15, CI 1.08–1.24, $p < 0.0001$) (Fig. 2B).

Only one study presented data on graft survival rates at 5 years. The authors found no significant difference with a 5-year graft survival of 73.1% in the LTA group and 77.6% in the CLKT group ($p = 0.368$) [22]. Statistical heterogeneity was high for the outcome at 1 year (I^2 87%) and low for the 3-year outcome (I^2 0%).

3.4. Postoperative outcomes

Li et al. [16] presented data on hepatic allograft rejection, which was not significantly different between CLKT and LTA patients (33.3% versus 16.0% respectively, $p = 0.17$). Li et al. also presented data on primary non-function of the liver. One patient in the group receiving LTA died due to primary non-function (4%), and zero in the CLKT group.

3.5. Kidney after liver transplantation

One study [15] presented incidence of renal transplantation after initial LTA. After one year, 4.1% had received a subsequent kidney transplant (KALT, kidney after liver transplant). Three years after initial liver transplant, 7.4% had received a kidney graft. Another study [14] performed a subgroup analysis on patients who received an early (60 to 365 days after initial liver transplant) and late (365 days to 2 years after initial liver transplant) KALT. Of all 19,392 patients analyzed, 120 patients (0.6%) received an early KALT and 145 patients (0.75%) a late KALT.

3.6. Quality of evidence

All included studies received full scores in all categories of the NOS (Table 1).

4. Discussion

Our results show that CLKT has similar survival outcomes as LTA in patients with both end stage liver disease and renal dysfunction with a trend towards better long-term survival in CLKT patients. These results are expected, as CLKT is a treatment for both the liver and kidney disease. The risk of liver graft loss at 3 years is significantly lower in

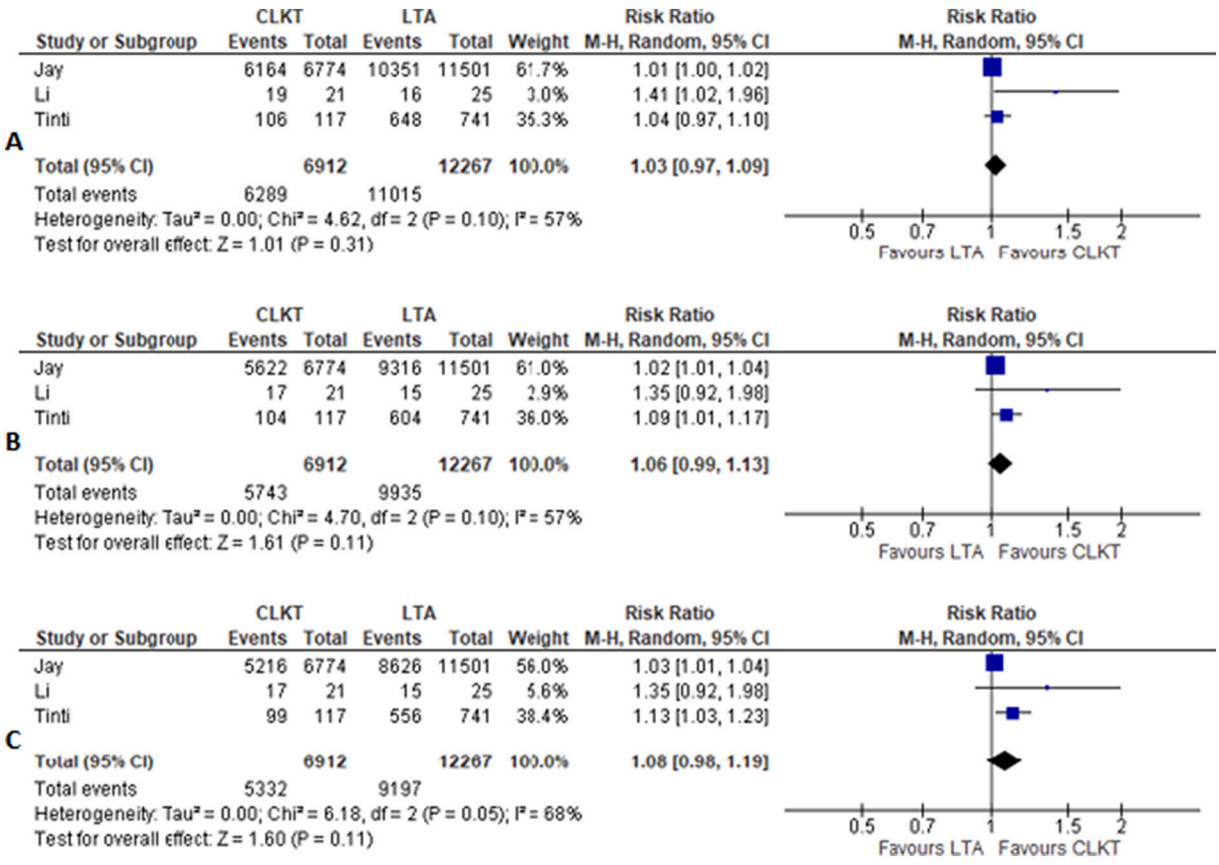

Fig. 1. Mortality risk in CLKT vs LTA. A: 1 year mortality risk. B: 3 year mortality risk. C: 5 year mortality risk.

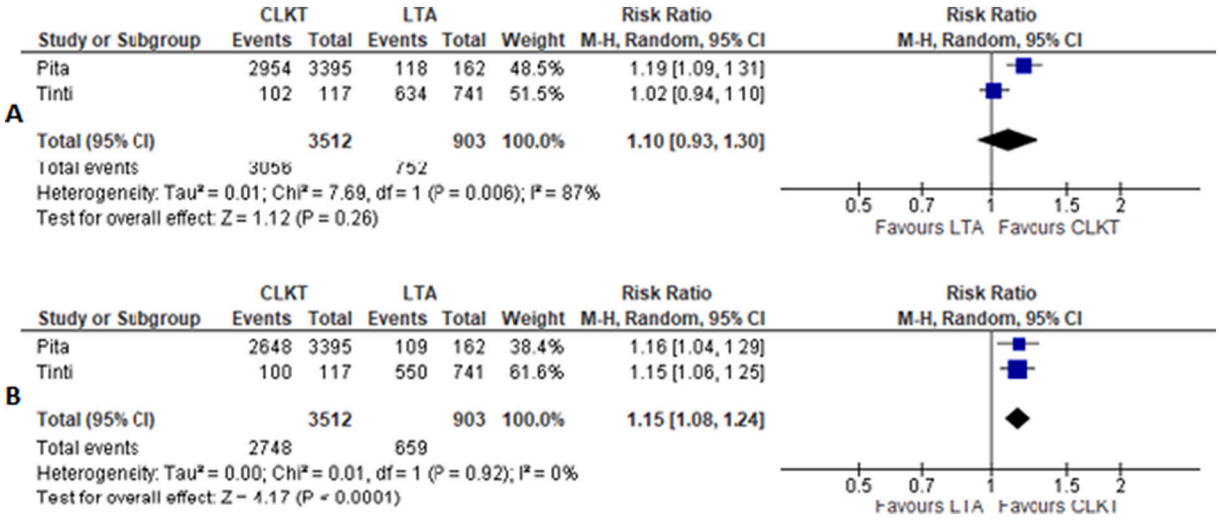

Fig. 2. Risk of liver graft loss in CLKT compared to LTA. A: 1 year risk of graft loss. B: 3 year risk of graft loss.

patients with renal dysfunction who received CLKT compared to LTA. This can be explained by the difference in immunosuppressive regimen between patients receiving CLKT or LTA.

One interesting point of discussion is at which KDIGO stage of renal dysfunction CLKT is superior to LTA with regard to survival outcomes. The UNOS allocation policy for CLKT states that patients are eligible for CLKT if they fall into one of three categories: the eGFR $\leq$60 ml/min for 90 consecutive days and eGFR $\leq$30 ml/min at registration on kidney waiting list or receive dialysis in case of chronic kidney disease; eGFR $\leq$25 ml/min or receive dialysis for 6 consecutive weeks in case of acute kidney injury; or have a confirmed metabolic disease affecting both liver and kidney. This allocation policy was implemented to reduce the amount of CLKT being performed to optimize utilization of scarce donor organs. However, a recent study shows that, despite the implementation of the new allocation policy, no decline was observed in patients waitlisted for CLKT [23].

One study [22], included in our meta-analysis, stratified patients based on estimated GFR and showed that the advantage of CLKT only exists in patients receiving chronic RRT at time of transplant. Based on this study, allocation of CLKT may be limited to patients on RRT.

However, the three other studies have not stratified for estimated GFR, making a subgroup analysis to substantiate this statement impossible. It is possible that patients receiving a CLKT would benefit more from receiving a LTA, and possibly a kidney transplant at a later date if they are not receiving chronic RRT yet. Large data is lacking on this subject, but in the included studies that presented data on this topic, incidence of KALT was low. Wait listing patients for a KALT could result in less kidney transplants if kidney function improves after liver transplant, which means the donor kidney could be allocated to someone else, leading to better utilization of kidney grafts. This is called the "safety net prioritization" and has been implemented in the USA since 2017. In this "safety net", liver transplant recipients who failed to recover native renal function after LTA (eGFR <20 ml/min between 60 and 365 days after transplant) were allocated kidneys ahead of local adult kidney alone candidates from donors with a KDPI >20% [24]. Since this "safety net" implementation, CLKT utilization has only decreased with 16% and KALT utilization has increased [24]. A recent study has analyzed results from the UNOS database and compared risk of kidney failure in KALT to CLKT. They found that recipients with a MELD score $\geq$ 25 have a significantly higher risk of ninety-day and one year kidney allograft failure if they receive CLKT instead of KALT (3.3% versus 7.3%, $p <$ 0.001 and 5.1% versus 12.3%, p < 0.001 respectively) [25]. They performed a separate analysis focusing only on KALT wherein recipients received a kidney transplant within one year after liver transplant. Therein, they found that the threshold where CLKT is associated with higher risk of kidney failure than KALT, began at a MELD score of 33. This suggests that KALT could be beneficial for early kidney allograft outcome in patients with high MELD scores. On the other hand, a sequential kidney transplant would come from a different donor, possibly negating the immunological protection of the liver on kidney rejection and leading to recipients receiving more donor antigens.

Another option described in literature is delayed kidney implantation [26,27], in which the kidney of the same donor is transplanted more than 48 h after the liver transplant and until transplant kept on continuous hypothermic pulsatile machine perfusion. Ekser et al. first performed this method of delayed implantation, and described that this is associated with improved kidney function, less delayed graft function and improved patient and graft survival. The rationale behind this delayed implantation is that elevated bilirubin levels, coagulopathy and perioperative hemodynamic state of patients receiving CLKT are detrimental to the kidney graft and can cause delayed graft function and graft failure. The downside of this method is the longer cold ischemia time of the kidney graft which could lead to worse kidney graft survival outcomes [28].

This meta-analysis is the first to compare results between CLKT and LTA in presence of renal dysfunction. Strengths of our study are the careful deduplication of overlapping study cohorts. Our meta-analysis also has some limitations, the most important one being the moderate to high heterogeneity due to selection bias and the observational, retrospective nature of the studies. Selection bias occurred because transplant centers often decided eligibility for CLKT on a case-by-case basis before 2017 when the UNOS allocation policy was introduced. The definition of renal dysfunction was not the same between the included studies, with two articles only including patients receiving RRT at time of transplant while one study included all patients with renal dysfunction. As this means that control groups between studies differed, this could have influenced some of the observed heterogeneity. This difference can also be found in the baseline characteristics, where the incidence of RRT at time of transplant was higher in the CLKT group compared to LTA and serum creatinine was significantly higher.

Tinti et al. showed that CLKT only provides better survival outcomes in patients on RRT. Because we pooled all KDIGO stages for renal dysfunction, this may explain why long-term survival outcomes were not superior after CLKT.

In the future, a prospective study comparing outcomes of patients who receive a CLKT compared to patients who receive a KALT via the "safety net allocation" will prove useful to determine when to waitlist a patient for CLKT or LTA. A sub-analysis on the causes of liver and kidney dysfunction would also be clinically relevant because metabolic diseases are listed separately in the current allocation policy.

In conclusion, combined liver-kidney transplants seem to be an appropriate therapeutic option for patients with both end stage liver disease and renal dysfunction. However, more data is necessary to determine which patients, with which KDIGO stage of renal dysfunction, benefit the most from CLKT. This is especially important as alternative schemes for combining LT with KT are possible and already starting to get implemented. This may lead to a more optimal use of scarce donor organs. Future studies should focus on further defining severity of renal dysfunction in order to have a survival benefit of CLKT over LTA.

Disclosure

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

Sarah Bouari: Declarations of interest: none.
Elsaline Rijkse: Declarations of interest: none.
Herold J. Metselaar: Declarations of interest: none.
Martijn W.F. van den Hoogen: Declarations of interest: none.
Jan N.M. IJzermans: Declarations of interest: none.
Jeroen de Jonge: Declarations of interest: none.
Wojciech G. Polak: Declarations of interest: none.
Robert C. Minnee: Declarations of interest: none.

Acknowledgements

The authors wish to thank the faculty of the Erasmus MC Medical Library for developing and updating the search strategies.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trre.2021.100633.

References

[1] Gentili F, Giusto M, Loria I, Ginanni Corradini S, Molinaro A, Attili AF, et al. Chronic renal dysfunction after liver transplantation: risk factors and a new predictive score. J Hepatol 2009;50:S175.
[2] Tanriover B, Mejia A, Weinstein J, Foster SV, Ghalib R, Mubarak A, et al. Analysis of kidney function and biopsy results in liver failure patients with renal dysfunction: a new look to combined liver kidney allocation in the post-MELD era. Transplantation 2008;86:1548–53.
[3] David Hall A, Modanlou K, Wong E, Eason J, Yoo M, Satapathy S, et al. Older liver recipients with renal dysfunction benefit from combined liver-kidney transplant vs. liver transplant. Am J Transplant 2015;15:93–4.
[4] Davis CL, Gonwa TA, Wilkinson AH. Identification of patients best suited for combined liver-kidney transplantation: part II. Liver Transplant 2002;8:193–211.
[5] Chava SP, Singh B, Zaman MB, Rela M, Heaton ND. Current indications for combined liver and kidney transplantation in adults. Transplant Rev 2009;23:111–9.
[6] Nadim MK, Sung RS, Davis CL. Simultaneous liver–kidney transplantation summit: current state and future directions. Am J Transplant 2012 :2901–8.
[7] Ekser B, Contreras AG, Andraus W, Taner T. Current status of combined liver-kidney transplantation. Int J Surg 2020;82S:149–54.
[8] Pham PTT, Lunsford KE, Bunnapradist S, Danovitch GM. Simultaneous liver-kidney transplantation or liver transplantation alone for patients in need of liver transplantation with renal dysfunction. Curr Opin Organ Transplant 2016;21:194–200.
[9] Formica RN, Aeder M, Boyle G, Kucheryavaya A, Stewart D, Hirose R, et al. Simultaneous liver-kidney allocation policy: a proposal to optimize appropriate utilization of scarce resources. Am J Transplant 2016;16:758–66.
[10] Asch WS, Bia MJ. New organ allocation system for combined liver-kidney transplants and the availability of kidneys for transplant to patients with stage 4-5 CKD. Clin J Am Soc Nephrol 2017;12:848–52.

[11] Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ 2009;339:b2535.
[12] Wells BSGA, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. 2011.
[13] Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol 2014;14:135.
[14] Jay CL, Washburn WK, Rogers J, Harriman D, Heimbach J, Stratta RJ. Difference in survival in early kidney after liver transplantation compared with simultaneous liver-kidney transplantation: evaluating the potential of the "safety net". J Am Coll Surg 2020;230:463–73.
[15] Pita A, Kaur N, Emamaullee J, Lo M, Nguyen B, Sabour A, et al. Outcomes of liver transplantation in patients on renal replacement therapy: considerations for simultaneous liver kidney transplantation versus safety net. Transplant Direct 2019;5:e490.
[16] Li H, Fan MQ, Men TY, Wang YP, Xing TH, Fan JW, et al. Long-term outcomes of simultaneous liver-kidney transplant patients with hepatitis B compared to with liver transplant alone. Med Sci Monit 2016;22:332–40.
[17] Tinti F, Mitterhofer AP, Umbro I, Nightingale P, Inston N, Ghallab M, et al. Combined liver–kidney transplantation versus liver transplant alone based on KDIGO stratification of estimated glomerular filtration rate: data from the United Kingdom Transplant registry – a retrospective cohort study. Transplant Int 2019;32:918–32.
[18] Aguilera V, Ferrer I, Berenguer M, Rivera J, Rubín Á, Moya Á, et al. Comparison of results of combined liver-kidney transplantation vs. isolated liver transplantation. Ann Hepatol 2013;12:274–81.
[19] Catalano G, Tandoi F, Mazza E, Simonato F, Tognarelli G, Biancone L, et al. Simultaneous liver-kidney transplantation in adults: a single-center experience comparing results with isolated liver transplantation. Transplant Proc 2015;47:2156–8.
[20] Martin EF, Huang J, Xiang Q, Klein JP, Bajaj J, Saeian K. Recipient survival and graft survival are not diminished by simultaneous liver-kidney transplantation: an analysis of the united network for organ sharing database. Liver Transplant 2012;18:914–29.
[21] Xing T, Zhong L, Chen D, Peng Z. Experience of combined liver-kidney transplantation for acute-on-chronic liver failure patients with renal dysfunction. Transplant Proc 2013;45:2307–13.
[22] Tinti F, Mitterhofer AP, Umbro I, Nightingale P, Inston N, Ghallab M, et al. Combined liver-kidney transplantation versus liver transplant alone based on KDIGO stratification of estimated glomerular filtration rate: data from the United Kingdom Transplant registry - a retrospective cohort study. Transpl Int 2019;32:918–32.
[23] Cullaro G, Hirose R, Lai JC. Changes in simultaneous liver-kidney transplant allocation policy may impact postliver transplant outcomes. Transplantation 2019;103:959–64.
[24] Wiseman AC. Simultaneous liver-kidney transplant: long-term management (steroid withdrawal and safety net patients). Clin Liver Dis (Hoboken) 2019;13:176–9.
[25] Cullaro G, Verna EC, Emond JC, Orandi BJ, Mohan S, Lai JC. Early kidney allograft failure after simultaneous liver-kidney transplantation: evidence for utilization of the safety net? Transplantation 2021;105:816–23.
[26] Ekser B, Mangus RS, Fridell W, Kubal CA, Nagai S, Kinsella SB, et al. A novel approach in combined liver and kidney transplantation with long-term outcomes. Ann Surg 2017;265:1000–8.
[27] Lunsford KE, Agopian VG, Yi SG, Nguyen DTM, Graviss EA, Harlander-Locke MP, et al. Delayed implantation of pumped kidneys decreases renal allograft futility in combined liver-kidney transplantation. Transplantation 2020;104:1591–603.
[28] Debout A, Foucher Y, Trebern-Launay K, Legendre C, Kreis H, Mourad G, et al. Each additional hour of cold ischemia time significantly increases the risk of graft failure and mortality following renal transplantation. Kidney Int 2015;87:343–9.