Review

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Normothermic Ex Situ Heart Perfusion With the Organ Care System for Cardiac Transplantation: A Meta-analysis

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Background. Heart transplantation (HTx) is, at present, the most effective therapy for end-stage heart failure patients; however, the number of patients on the waiting list is rising globally, further increasing the gap between demand and supply of donors for HTx. First studies using the Organ Care System (OCS) for normothermic machine perfusion show promising results yet are limited in sample size. This article presents a meta-analysis of heart donation either after brain death (OCS-DBD) or circulatory death (OCS-DCD) on using OCS versus static cold storage used for HTx. **Methods.** A systematic literature search was performed for articles discussing the use of normothermic ex situ heart perfusion in adult patients. Thirty-day survival outcomes were pooled, and odds ratios were calculated using random-effects models. Long-term survival was visualized with Kaplan-Meier curves, hazard ratios were calculated and pooled using fixed-effects models, and secondary outcomes were analyzed. **Results.** A total of 12 studies were included, with 741 patients undergoing HTx, of which 260 with the OCS (173 DBD and 87 DCD). No differences were found between the 3 groups for early and late survival outcomes or for secondary outcomes. **Conclusions.** OCS outcomes, for both DBD and DCD hearts, appeared similar as for static cold storage. Therefore, OCS is a safe and effective technique to enlarge the cardiac donor pool in both DBD and DCD, with additional benefits for long-distance transport and surgically complex procedures.
(Transplantation 2022;106: 1745–1753).

Received 13 January 2022. Revision received 4 March 2022.

Accepted 4 March 2022.

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The authors declare no funding or conflicts of interest.

J.H.A., S.J.J.L., and Y.J.H.J.T. conceived the idea for the presented research. S.J.J.L. and J.H.A. contributed equally to the study design, literature screening, and writing of this article. S.J.J.L and K.M.V. participated in the statistical analysis. A.J.J.C.B., O.C.M., and Y.J.H.J.T. contributed to drafting and critical review of the article. All authors approved the article for submission.

Supplemental Visual Abstract; http://links.lww.com/TP/C427.

Supplemental digital content (SDC) is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (www.transplantjournal.com).

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ISSN: 0041-1337/20/1069-1745

DOI: 10.1097/TP.0000000000004167

INTRODUCTION

Heart failure (HF) is a rising global epidemic, affecting at least 63 million people worldwide.[1,2] Despite improved therapeutic approaches and interventions, the number of patients with end-stage HF is still increasing,[2,3] and for those who are eligible, heart transplantation (HTx) remains the gold standard. Furthermore, the use of bridging ventricular assist device therapy is increasing, leading to a discrepancy between demand and supply with higher mortality while waiting for a suitable donor heart.[3-5]

Until recently, donation after brain death (DBD) donors were the only heart donors that could be used for HTx worldwide. Although the number of DBD donors has increased during the past years in most regions, the demand for donor hearts still exceeds its supply. This necessitates further expansion of the donor pool, and after exhausting possibilities to do so within the DBD donor pool by increasing the use of marginal organs, interest shifted toward donation after circulatory death (DCD)[5-8]; however, issues about unquantifiable warm ischemic injury to the myocardium together with the inability to assess function in the asystolic heart hampered attempts to use DCD hearts for transplantation.[9]

To address those issues, the Organ Care System (OCS) Heart based on normothermic ex situ heart perfusion (ESHP) was created by TransMedics Inc (Andover, MA).[10,11] By using an ESHP setup, DCD hearts can be used for HTx.[12] In addition, more cardiac transplantations are achievable because of the possibility of long-distance

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travel,[13,14] inclusion of more surgically complex procedures,[15] and use of marginal donors and recipients.[16,17] Recent studies have already shown great potential to enlarge the donor pool,[18] with calculated increases of 4% to 56%[19-22] and reported increases of up to 48% using hearts from DCD donors.[23-25]

Established OCS HTx programs provide promising results advocating a worldwide expansion of those programs; however, studies are limited in sample size and are mostly single centered. Therefore, we aimed to address the question of whether DBD or DCD OCS perfused hearts present at least equivalent outcomes compared with DBD hearts using static cold storage (SCS) as a preservation method.

MATERIALS AND METHODS

Search Strategy

A systematic review of the literature was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 Statement.[26]

Embase, Medline, Web of Science, Cochrane, and Google Scholar were systematically searched with the help of a biomedical librarian on March 16, 2021. The following key terms were used for all databases: heart transplantation, organ/heart perfusion, organ care system, normothermia, and ex situ, isolated/machine perfusion. Full search terms can be found in the **Supplemental Materials** (**SDC**, http://links.lww.com/TP/C426).

Eligibility Criteria

Studies using normothermic ESHP for adult cardiac transplantation that reported on graft and patient outcomes were eligible for inclusion. Only randomized controlled trials (RCTs) and cohort studies performed in humans were selected. Studies were excluded if normothermic regional perfusion was used for organ procurement or if cardiac conditioning methods were applied during normothermic perfusion. Moreover, overlapping populations were allowed in case they reported any additional information on follow-up of primary or secondary outcomes. For meta-analysis, if the same outcomes were reported more than once from studies with overlapping populations, only those outcomes from the study with the largest number of patients were included.

All titles and abstracts were screened by 2 independent reviewers (S.J.J.L. and J.H.A.). Both authors screened the remaining full-text articles, and reasons for exclusion were recorded.

Data Extraction

Data were extracted from all included articles, using a prespecified data extraction format in Microsoft Office Excel, version 16.0, containing study characteristics, patient characteristics, type of organ donation, operation characteristics, and transplantation outcomes. Transplantation outcomes included primary graft dysfunction (PGD), duration of intensive care unit (ICU) and hospital stay, 30-d patient survival, long-term survival, rejection, and cardiac allograft vasculopathy (CAV).

Quality Assessment

The Cochrane Risk of Bias tool[27] was used to assess quality of RCTs, and the Newcastle-Ottawa Quality Assessment Scale for cohort studies was used for other studies.[28]

Statistical Analysis

Sample size weighted pooled baseline and operative characteristics were calculated, using both means and medians. Thirty-day mortality was pooled in R (version 4.0.3; R Foundation for Statistical Computing, Vienna, Austria)[29] with a random-effects meta-analysis of single proportions using a generalized linear mixed model and a logit transformation to calculate an overall proportion. Additionally, pooled odds ratios (ORs) for 30-d mortality of studies that had a comparison group were calculated using the Mantel-Haenszel method for pooling, with a random-effects model using the Paule-Mandel estimator to estimate between-study variance. The Cochrane Q statistic and I^2 were used to assess heterogeneity.

Kaplan-Meier (KM) curves from individual studies were extracted and pooled using a method described by Guyot et al.[30] Original patient data were reconstructed using the Engauge Digitizer, version 12.1,[31] to create a list of coordinates of the original KM curves and using an algorithm written in R. Pooled KM curves were plotted in R, and 1-y and 4-y survival curves were extracted from pooled data. Pooled data of individual studies were also used to create univariate Cox regression models to obtain hazard ratios (HRs) and were then pooled and analyzed with a fixed-effects model using the inverse variance method, as <3 studies were pooled.[32] A P value <0.05 was considered statistically significant.

RESULTS

The literature search resulted in 1706 unique records, where 107 articles remained for eligibility control, of which 12 studies met the inclusion criteria (9 DBD and 3 DCD; Figure 1).[16,17,23-25,33-39]

This resulted in a study population of 741 patients who underwent HTx, of which 260 (35.1%) were performed using the OCS and 481 (64.9%) using SCS. One study was an RCT, 8 were cohort studies, and 3 were (subgroup) follow-up studies from earlier cohorts (**Table S1, SDC,** http://links.lww.com/TP/C426). Studies were performed in the United States, Australia, United Kingdom, Germany, Italy, and Kazakhstan and were conducted between 2006 and 2020. All studies used the Transmedics OCS, as it is currently the only commercially approved device in clinical use.

Quality Assessment

The overall risk of bias was low in all studies, with all cohort studies scoring a minimum of 6 of 9 points on the Newcastle-Ottawa Quality Assessment Scale (**Table S2, SDC,** http://links.lww.com/TP/C426). The Cochrane Risk of Bias tool also showed low risk of bias in the RCT[33] (**Table S3, SDC,** http://links.lww.com/TP/C426).

Baseline Characteristics

Table 1 presents an overview of the baseline and operative characteristics for patients receiving HTx from a DBD donor on OCS (OCS-DBD group), patients receiving a heart from a DCD donor on OCS (OCS-DCD group), or patients receiving conventional HTx, preserved with SCS (SCS-DBD group), along with their sample size pooled means.

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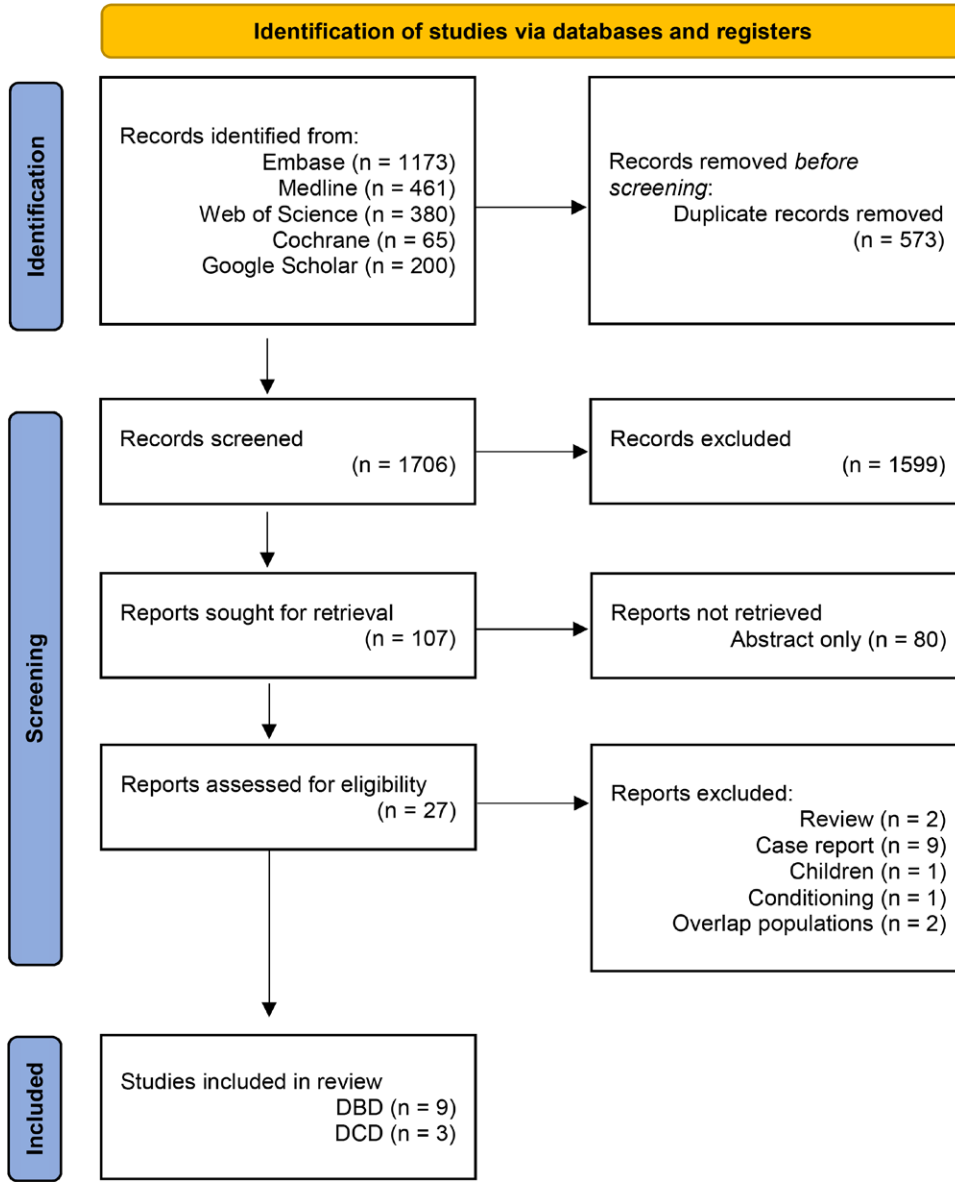

FIGURE 1. PRISMA flow diagram of the literature search and selection process. DBD, donation after brain death; DCD, donation after circulatory death; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Percentage male donor sex was higher in the OCS-DCD group (86% versus 68% OCS-DBD and 69% SCS-DBD), and donors also appeared to be the youngest in this group (32 y versus 39 y OCS-DBD and 38 y SCS-DBD).

Pooled out-of-body time appears longer in the OCS-DBD group than in the SCS-DBD group (331 versus 208 min), but pooled total ischemic time was shorter in the OCS-DBD group (102 versus 208 min). No ischemic times were reported for individual studies in the OCS-DCD group.[23-25]

In the OCS-DBD and SCS-DBD groups, one study specifically investigated the use of marginal donor hearts,[17] another the use of OCS for recipients on mechanical circulatory support (MCS) that are therefore more high risk,[39] and one study looked at the use of OCS for both marginal donors and recipients[16] (**Table S1, SDC,** http://links.lww.com/TP/C426). The other OCS-DBD studies used routine donors and recipients.[33-38]

Short-term Survival

Pooled 30-d survival was 97.4% (95% confidence interval [CI], 88.5%-99.4%) for the OCS-DBD group, 96.6% (95% CI, 89.9%-98.9%) for the OCS-DCD group, and 95.7% (95% CI, 93.1%-97.3%) for the SCS-DBD group. No differences in short-term survival between OCS-DBD and OCS-DCD, compared with SCS-DBD methods, were found in the pooled ORs for 30-d survival (Figure 2).

Long-term Survival

Six studies contained KM curves that could be reconstructed, pooled, and used for univariable Cox regression, resulting in the pooled KM curves as presented in Figure 3, with overlapping curves throughout follow-up. Pooled 1-y survival was 84.2% for the OCS-DBD group, 89.3% for the OCS-DCD group, and 87.0% for the SCS-DBD group. Pooled 4-y survival was 82.2%, 85.3%, and 80.3%, respectively.

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TABLE 1.

Baseline and operative characteristics

		Donor characteristics		Recipient characteristics			Operative characteristics		
Author	N	Age (y)	Male %	Age (y)	Male %	MCS pre-HTx %	Out-of-body time (min)	Total ischemia time (min)	OCS time (min)
OCS-DBD group									
Ardehali[33]	67	35 (range, 18–58)	66	56 (range, 20–75)	82	27	324 ± 79	113 ± 27	211
Chan[34,a]	19	30.9 ± 13.1	79	51.9 ± 11.8	74	32	–	361 ± 96	–
García Sáez[16]	26	37 ± 12	77	43 ± 13	81	50	371 ± 102	87 ± 15	285 ± 92
Kaliyev[35]	13	43 ± 15.5	69	40 ± 12	69	69	330.3	82.9 ± 8.4	247.4 ± 88.4
Koerner[36]	29	36 (range, 17–54)	62	50.1 (range, 37–64)	76	41	297	52	245 (range, 176–343)
Mehta[25]	3	42 (range, 41–50)	67	56.7 (range, 27.4–61.1)	100	33	–	–	270 (range, 180–313)
Pya[37,a]	43	43 ± 15.5	69	40 ± 12	69	69	330.3	82.9 ± 8.4	247.4 ± 88.4
Sato[38,a]	16	–	–	51.8 ± 15.5	60	60	362 ± 153	114 ± 51	248
Sponga[39]	14	46 ± 11	79	64 (range, 35–75)	100	100	452	132 ± 28	320 ± 76
Sponga[17]	21	47 ± 11	62	58 (range, 24–66)	76	–	272 ± 65	145 ± 29	127
Pooled values	173	39	68	53	81	41	331	102	230
OCS-DCD group									
Chew[24]	23	29 ± 6	83	52 ± 13	74	35	–	–	276 ± 67
Mehta[25]	7	28 (range, 21–42)	100	58 (range, 27–59)	86	71	–	–	263 (range, 200–304)
Messer[23]	57	34 (IQR, 27–39)	86	55 (IQR, 48–61)	75	33	–	–	251
Pooled values	87	32	86	54	76	37	–	–	258
SCS-DBD group									
Ardehali[33]	63	34 (range, 13–60)	71	57 (range, 20–76)	71	24	195 ± 65	195 ± 65	/
Chan[34,a]	19	31.8 ± 13.5	68	59.9 ± 11.8	63	21	207 ± 50	207 ± 50	/
Chew[24]	106	33 ± 10	66	51 ± 14	61	–	–	–	/
Koerner[36]	130	–	–	50.7 (range, 37–64)	83	58	–	–	/
Messer	79	38 (IQR, 30–50)	81	55 (IQR, 49–60)	81	28	–	–	/
Sato[38,a]	18	–	–	59.1 ± 16.2	85	8	183 ± 34	183 ± 34	/
Sponga[39]	24	44 ± 13	75	57 (range, 30–73)	88	83	225 ± 48	225 ± 48	/
Sponga[17]	79	48 ± 13	58	60 (range, 28–73)	82	–	213 ± 63	213 ± 63	/
Pooled values	481	38	69	54	77	45	208	208	/

[a]Substudies with overlapping populations, not used in pooled baseline values.

–, not reported; /, not applicable; HTx, heart transplantation; IQR, interquartile range; MCS, mechanical circulatory support; OCS-DBD, donation after brain death hearts perfused on the Organ Care System; OCS-DCD, donation after circulatory death hearts perfused on the Organ Care System; SCS-DBD, donation after brain death hearts preserved with static cold storage.

HRs could be calculated from 4 of the 6 curves, as 1 study did not contain a comparison group[35] and 1 study had 0 events[17] in the intervention group. A continuity correction was not feasible because of the small sample size. HRs were included in a fixed-effects meta-analysis, also showing no significant differences between OCS-DBD, OCS-DCD, and SCS-DBD groups on long-term survival (Figure 4).

Secondary Outcomes

Many individual studies did not find a significant difference in PGD between the OCS and conventional

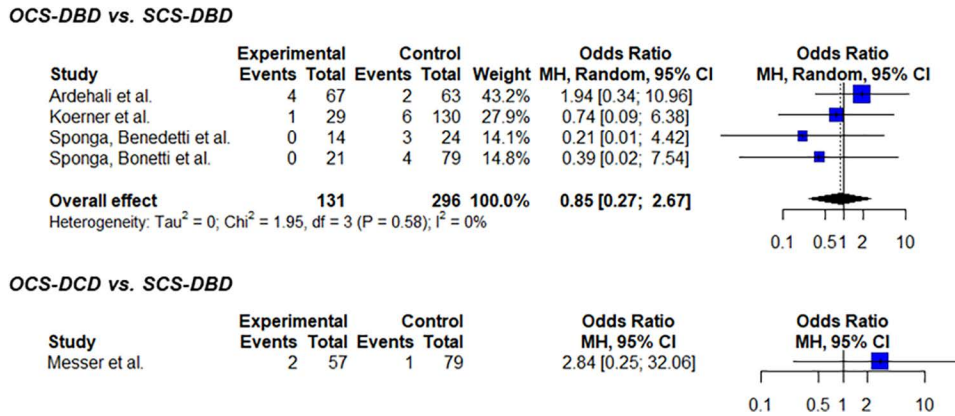

FIGURE 2. Forest plots of the results of a meta-analysis for ORs of 30-d survival. CI, confidence interval; MH, Mantel-Haenszel; OCS-DBD, donation after brain death hearts perfused on the Organ Care System; OCS-DCD, donation after circulatory death hearts perfused on the Organ Care System; OR, odds ratio; SCS-DBD, donation after brain death hearts preserved with static cold storage.

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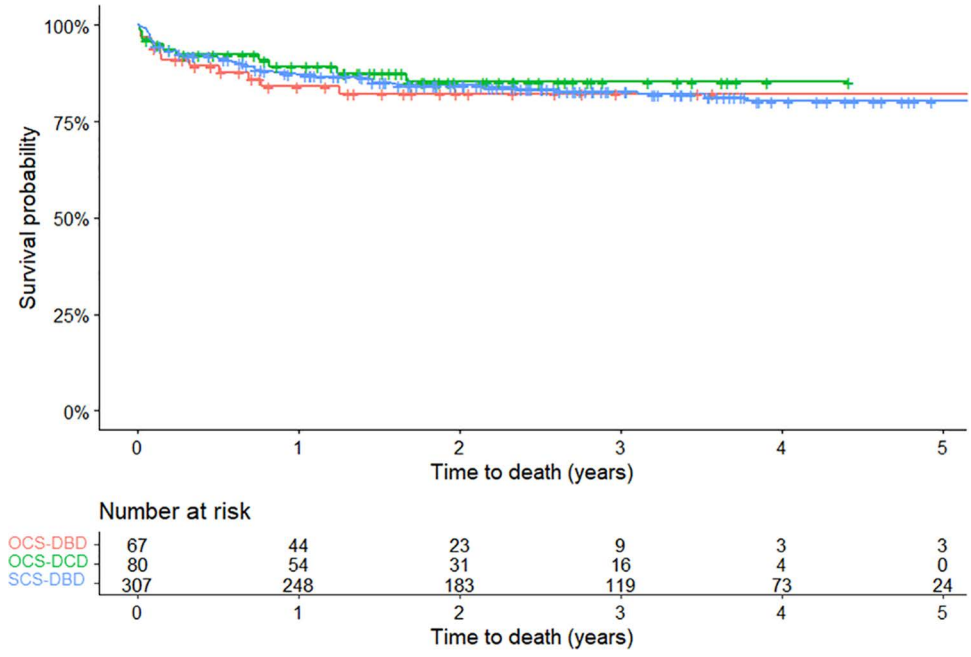

FIGURE 3. Pooled KM curves for long-term survival in OCS-DBD, OCS-DCD, and SCS-DBD groups. KM, Kaplan-Meier; OCS-DBD, donation after brain death hearts perfused on the Organ Care System; OCS-DCD, donation after circulatory death hearts perfused on the Organ Care System; SCS-DBD, donation after brain death hearts preserved with static cold storage.

transplantation,[33,35,36,39] apart from 1 study finding a lower rate of moderate to worse PGD in their OCS-DBD group[17] and 1 study reporting higher rates of immediate graft dysfunction and extracorporeal membrane oxygenation (ECMO) requirement within their OCS-DCD cohort. Yet, in the latter one, all hearts recovered to normal biventricular function at 1 wk after transplantation.[24]

No significant differences in rejection were found in 6 studies between OCS-DBD and SCS-DBD groups during a follow-up period ranging from 30 d to 5 y.[17,33,34,36,38,39] OCS-DCD versus SCS-DBD studies also did not find a difference in rejection within the first year of follow-up.[23,24]

Incidence of CAV ranged between 0% and 17% for the OCS-DBD group and 5% and 23% for the SCS-DBD group in 6 studies, without differences reaching statistical significance in any individual study.[17,34,36-39] Linearized occurrence rate was 1.6% (95% CI, 0.3%-9.5%) per year for the OCS-DBD group and 4.5% (95% CI, 2.8%-7.2%) per year for the SCS-DBD group. Furthermore, Sato et al specifically studied the effect of the OCS on intimal thickening. They did not find any differences in intravascular ultrasound parameters between groups.[38] Specific CAV grades were not mentioned in most studies, and the longest follow-up was of 5 y.

Median ICU stay ranged between 5 and 8 d for most studies in the OCS-DBD group, with 1 exception of 19 d,[16,17,25,33,35,39] between 7 and 14 d for the OCS-DCD,[23-25] and between 6 and 11 d for the SCS-DBD group.[17,23,24,33,39]

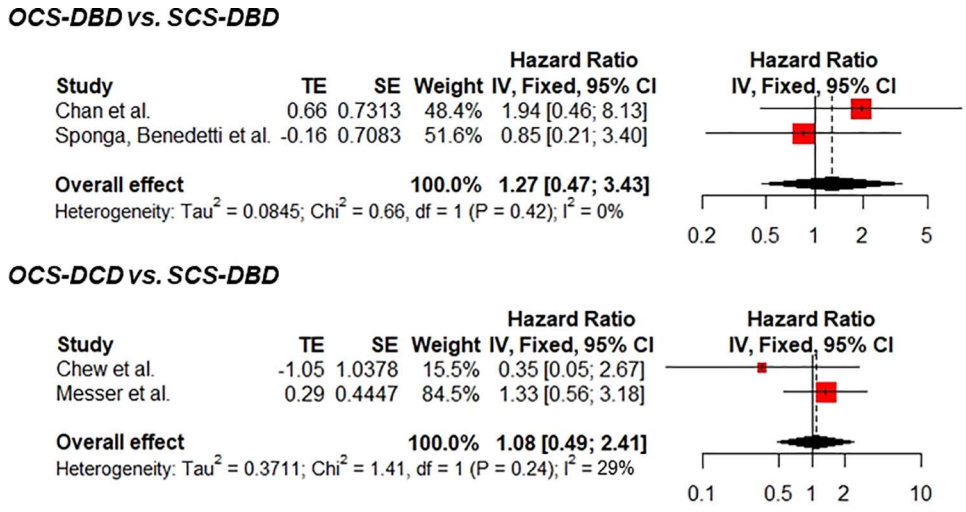

FIGURE 4. Forest plots of the results of a meta-analysis for HRs of long-term survival. CI, confidence interval; HR, hazard ratio; IV, inverse variance; OCS-DBD, donation after brain death hearts perfused on the Organ Care System; OCS-DCD, donation after circulatory death hearts perfused on the Organ Care System; SCS-DBD, donation after brain death hearts preserved with static cold storage; TE, treatment effect; SE, standard error.

None of the studies found a statistically significant difference between OCS and SCS groups (**Table S4, SDC,** http://links.lww.com/TP/C426).

Total duration of hospital stay varied between medians of 26 and 32 d and a mean of 39 d, with 1 outlier of 61 d in the OCS-DBD group,[16,17,25,36,39] between 24 and 31 d in the OCS-DCD group,[23-25] and between 25 and 40 d in the SCS-DBD group.[17,23,24,36,39] Values were not pooled, but no significant differences were found within individual studies (**Table S5, SDC,** http://links.lww.com/TP/C426).

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DISCUSSION

We provide a comprehensive overview of normothermic machine perfusion as an organ preservation method for cardiac transplantation. To our knowledge, this is the first meta-analysis comparing the OCS to conventional SCS.

Outcomes of this meta-analysis show comparable outcomes for both OCS-DBD and OCS-DCD versus SCS-DBD hearts, suggesting that normothermic ESHP can be used safely and effectively for HTx with no apparent differences in early and late survival or secondary outcomes.

Baseline Characteristics

Donors were generally younger for the OCS-DCD group, which could be because of a lower age restriction for donation because DCD programs have only recently been established. Also, donors in the OCS-DCD group were more often male than in the OCS-DBD and SCS-DBD groups. In addition, OCS-DCD recipients received MCS pre-HTx less frequently, which could all be in favor of the OCS-DCD group. Although none of the individual studies found a significant difference between patient groups, it is well established that female donor sex, older age in either donor or recipient, female donor to male recipient transplantation, and pre-HTx bridging with MCS are risk factors for mortality and graft failure after HTx.[40,41] Furthermore, in the OCS-DBD and SCS-DBD groups, 3 studies specifically investigated marginal donors and recipients,[16,17,39] whereas the other studies used routine donors and recipients. This should be kept in mind when interpreting differences in outcomes between OCS-DBD and OCS-DCD groups, as a better profile for either donor or recipient hearts could lead to bias in favor of the OCS-DCD group.

Additionally, total out-of-body time was longer in the OCS-DBD group than in the SCS-DBD group, which can be explained by longer transport times and more complex surgical procedures for this group, necessitating the use of an OCS system in the first place. The same result is to be expected for the OCS-DCD group when compared with the SCS-DBD group, but none of the included OCS-DCD studies reported their total out-of-body time.

Survival

For short-term survival, pooled 30-d survival had fully overlapped 95% CIs, strongly suggesting that there is no difference between the 3 groups, although no test could be performed. This is corroborated by the pooled ORs that showed no statistically significant differences.

Long-term survival also showed no significant difference between groups through pooled HRs, and 1- and 4-y survival probabilities and KM curves were not far apart.

In all 3 groups, pooled 30-d survival was >95%, 1-y survival >84%, and 4-y survival >80%, which is comparable with internationally published data.[42]

OCS-DBD Versus SCS-DBD

Cold storage of donor hearts is a common practice worldwide, and convention dictates that cold ischemic time (CIT) should be limited to 4 h, especially among older donors.[43] Donors aged >18 y and CIT intervals exceeding 4 h have been associated with gradual but significantly diminished survival extending well beyond the perioperative period.[44]

The results of this meta-analysis show no significant differences in survival outcomes between DBD hearts transported on the using OCS and on SCS, although the OCS group has shorter total ischemic times. Therefore, the OCS is an asset to use when CIT is expected to exceed 4 h to reduce CIT and thus ensure graft quality.

OCS-DCD Versus SCS-DCD

The first successful HTx came from a donor with circulatory arrest[45]; however, out of fear of the harmful effects of warm ischemia and the fact that no in vivo functional assessment can be performed on an asystolic heart,[46] DCD heart donation was mostly abandoned for the ensuing years. Subsequently, only DBD hearts were used for transplantation for a long time. Four decades later, DCD hearts preserved with SCS were reintroduced for HTx in children.[47] It is well known that DBD donors show greater tolerance for prolonged ischemic times among grafts from younger donors.[43] Nevertheless, using SCS for DCD HTx, even in children, resulted in worse outcomes.[47,48]

The introduction of the OCS for DCD donors has surpassed most of those limitations and provides a strong case to be implemented into existing HTx programs.[9] The results of this meta-analysis corroborate with this statement, presenting equally good results for OCS-DCD hTx compared with the current gold standard, although longer follow-up studies are needed; however, high waiting list morbidity and mortality as well as the current positive results justify the wider implementation of OCS-DCD programs already while awaiting evidence from longer-term follow-up studies.

Secondary Outcomes

No relevant differences in ICU stay, hospital stay, PGD, or rejection were observed between the study groups. The reported variability in ICU and hospital stay between studies could be a result of different hospital discharge policies between countries.

One of the concerns before starting usage of the OCS was the potential of a higher incidence of CAV because of damage to the coronary endothelium; however, meta-analysis of linearized occurrence rates showed slightly less CAV occurring in OCS preserved hearts (OCS-DBD: 1.6%/y [95% CI, 0.3%-9.5%]; SCS-DBD: 4.5%/y [95% CI, 2.8%-7.2%]), which suggests that this is not the case. Similarly, studies investigating coronary endothelial function in left ventricular assist patients showed no impairment[49,50]; however, most studies did not report specific CAV grades, and follow-up was generally too short.[51]

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Future Perspectives

Normothermic ESHP has become a key player in expanding the donor pool for cardiac transplantation, as it allows for safer utilization of DCD and other marginal donors, limits CIT, and permits better due diligence for functional evaluation. The device has been used clinically for around 1.5 decades[36] but remains limited in its use, largely because of the sheer cost and need for specialized training before implementation of the technology. Nevertheless, the technique still has some potential areas of improvement that should be explored in the near future, and it is hoped that it would lead to more widespread use of ESHP to target donor shortages.

First, the optimal temperature for ESHP is a matter of debate. Normothermic blood-based machine perfusion most closely resembles the physiological state of the donor organ where aerobic metabolism continues without ATP depletion[46,52]; however, normothermic perfusion is more complex and requires higher metabolic demands at 34 to 37 °C with immediate organ damage upon possible technical failure. Compared with SCS hearts, hypothermic machine-perfused hearts showed preserved ATP levels and superior systolic function compared with SCS hearts,[52-56] yet they developed significant myocardial edema.[11] Moreover, no functional assessment is possible during hypothermic preservation, leading to much reluctance in implementing this technique, especially for marginal donor hearts.[57] Future studies should focus on the optimal temperature and type of perfusate, balancing between the degree of aerobic metabolism and formation of edema.

Second, the use of OCS has mostly been contained to the adult population because of certification of the device. Nevertheless, the OCS has recently been used in pediatric HTx procedures with very promising results.[15,58] Fleck et al[15] reported on the use of OCS in 8 children, compared with receiving conventional transplantation in 13 children. They found no difference in survival or other secondary outcomes between the 2 groups. Hence, these first studies indicate that the OCS might also be used in children as a feasible opportunity to enlarge the donor pool and to allow HTx in more complex congenital surgery; however, more research is needed to confirm these outcomes, and the OCS needs to be modified and approved for use in children because approval is now restricted to adults.

Third, the reanimation of donor hearts on the OCS permits valuable measurements of physiological and metabolic parameters and visual inspection of contractility, despite the lack of working-mode assessment.[11,59] Currently, differential lactate profile in blood samples from the OCS is the most important tool to assess tissue quality; however, the sensitivity of lactate levels for this purpose is questionable, especially when more marginal donors are in use.[60] Hence, additional functional parameters that provide real-time information on graft quality are needed, and research should focus on identifying more sensitive biomarkers of transplantability of donor hearts.

Finally, the OCS could also prove to be a useful platform for improving cardiac function before transplantation by means of cardiac conditioning. To date, the only clinical OCS studies applying cardiac conditioning during ESHP used levosimendan as a conditioning agent, along with the use of blood cardioplegia and hemofiltration.[35,37,61] They did not find any differences in survival or PGD outcomes, but secondary outcomes (lower ending concentrations of interleukin-6 and interleukin-8 and mean venous lactate, lower time to sinus rhythm restoration in the OCS, lower inotrope dose within 72 h, shorter median time on ECMO) were partly in favor of the levosimendan group.[35] Further studies are needed to further explore the potential of cardiac conditioning in combination with the OCS.

Limitations

This systematic review and meta-analysis contains mostly observational studies of a retrospective nature. Only 1 of the included study populations concerned an RCT, whereas most others are limited by the lack of a randomized and fully comparable control group, possibly leading to bias. Yet, the transplantation community is looking forward to the results of the ongoing DCD trial of Transmedics (ClinicalTrial.gov; number: NCT03831048).

Furthermore, some parameters were reported quite heterogeneously or not present for control groups, which complicated their meta-analysis. Therefore, single-arm pooling was performed for baseline characteristics, 30-d survival probabilities, and secondary outcomes. Yet, a limitation of this method is that no statistical tests can be performed on those values, as clustering of the data within underlying populations is not considered.

Additionally, because of the limited number of studies, statistical assessment of publication bias is impaired, which was therefore not performed but may play a role. Heterogeneity appeared to be low for pooled analyses.

CONCLUSION

This study provides an overview of clinical outcomes of the OCS for HTx in comparison with SCS. Transplantation of either OCS-DBD and OCS-DCD hearts appeared to be as good as SCS-DBD HTx in terms of early and late survival rates as well as secondary outcomes. Therefore, the OCS is a safe and effective technique to enlarge the cardiac donor pool and can be an asset for complex HTx cases.

ACKNOWLEDGMENTS

The authors would like to kindly thank Christa Niehot from the Erasmus MC Medical Library for developing and updating the search strategies.

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