

OCS Heart system for heart transplant

Medtech innovation briefing

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Summary

- The **technology** described in this briefing is the Organ Care System (OCS) Heart. It is a portable ex-vivo organ perfusion system to monitor and preserve a donor heart.
- The **innovative aspects** are that it is the only system available in clinical practice that may preserve a donor heart in a near-normothermic and beating state from retrieval until heart transplantation. Using the OCS allows hearts to be transported over longer distances than cold storage, and is the only available technology which allows donation after circulatory death. Both of these factors may result in an increased number of hearts suitable for donation.
- The intended **place in therapy** would be as an alternative to heart preservation using cold ischaemic storage in people needing heart transplantation. NICE interventional procedures guidance on [normothermic extracorporeal preservation of hearts for transplantation following donation after brainstem death](#) found that the evidence for short-term safety was sufficient for the procedure to be used with normal arrangements for clinical governance and audit.

- The **key points from the evidence** summarised in this briefing are from 5 studies published since December 2015 (n=158 transplants in total). Four studies were conference abstracts and therefore lacked detail on methodology. Two out of 5 studies were done outside the UK and all of the studies were single-centre, and so may not be generalisable to wider NHS populations. Overall, no adverse events were reported. Patients who received hearts donated after brainstem death and preserved using the OCS Heart system were found to have similar survival at 30 days and 2 years in comparison with cold storage preservation.
- **Key uncertainties** around the evidence and technology are that there is limited evidence for using the OCS Heart system for hearts that do not meet standard donor criteria.
- The **cost** of the single-use OCS Heart Perfusion Set is approximately £30,000 and the cost of the reusable Heart console is approximately £180,000. The cost of standard care using cold ischaemic storage would range from around £55 to £162.

The technology

The Organ Care System (OCS) Heart (TransMedics Inc.) is a portable ex-vivo organ perfusion system which can preserve a donor heart in a near-normothermic beating state from retrieval until it is transplanted.

The two main elements of the OCS Heart system are the OCS Heart console and the heart perfusion set, each of which contain several sub-components.

The OCS Heart console is an electromechanical, portable console with wireless monitor. It contains an infusion pump and circulatory pump, batteries, a data card, gas delivery subsystem, and probes.

The heart is continuously monitored whilst in the OCS Heart system. Physiological measurements include coronary flow, aortic flow, mixed venous haemoglobin saturation percentage, haematocrit percentage, blood temperature and pulmonary artery pressure. A coronary angiogram and electrocardiogram are also provided. Data from a blood gas analyser can also be entered into the system. Audible and visual alarms are given if any of these values move outside of accepted levels.

The OCS Heart console also provides a docking station for the portable monitor, and

storage for TransMedics maintenance solution. The OCS Heart console is reusable hardware that contains the components needed to drive and monitor the heart perfusion module, which is part of the heart perfusion set.

The heart perfusion set contains all of the components that directly contact blood or the heart during heart preservation. It is a single-use biocompatible perfusion and monitoring device, which includes the following:

- heart perfusion module, which provides the sterile blood circuit and protected environment for the heart in the OCS Heart system. The module communicates wirelessly with the console monitor. The heart sits in the organ chamber of this module.
- blood collection set, including a blood collection bag, line, clamp and a leukocyte filter set. The blood collection set is used to collect blood from the donor for donor heart perfusion. The blood passes through the leukocyte filter into the heart perfusion module reservoir.
- heart instrumentation tool set, a set of sterilised accessories for connecting the donor heart to the OCS Heart system.
- heart solution set, a 3-chamber system that delivers maintenance solution to the heart while it is in the OCS Heart system.
- cardioplegic arrest set, which is used to stop the donor heart using cold cardioplegia to be able to disconnect it from the OCS Heart system prior to transplantation.
- monitoring accessories package, containing valves to access the heart while it is being perfused on the OCS Heart system.

The donor heart is connected to the OCS Heart system immediately after explantation and is kept in a beating state until disconnection for transplant. The system maintains heart viability by continuously perfusing the donated heart with warmed, oxygenated blood, supplemented with TransMedics proprietary maintenance and priming solutions (which maintain the heart during transport while reducing the possibility of inflammatory reactions). The system needs at least 1,100 ml of blood from the heart donor. This blood is filtered with the TransMedics blood collection set and continuously circulated in a closed circuit with the TransMedics solutions. Implantation of the heart and subsequent patient care follow standard procedures.

The innovation

The technology is the only system available for use in clinical practice for donor heart preservation which allows near-normothermic blood-based perfusion of the donor heart. This technique aims to decrease the amount of damage that occurs to the heart after removal, by reducing the rate of tissue deterioration compared with conventional cold ischaemic storage. The OCS Heart system allows for hearts to be transported for longer distances in comparison with cold storage. It is the only available technology that allows donation after circulatory death (DCD). DCD is defined as death that has been diagnosed and confirmed using cardio-respiratory criteria, in contrast with donation after brainstem death (DBD) which uses neurological criteria to confirm death. There is a scarcity of suitable donor organs and DCD hearts are considered higher risk, so the use of OCS may increase the number of available donor hearts.

Current NHS pathway

People identified as needing a heart transplant are placed on a waiting list for a donor heart and are likely to wait for several months or years. Around half the people accepted onto the heart transplant waiting list have a transplant within 3 years, but for some people, a suitable heart does not become available.

People may be fitted with a ventricular assist device (VAD) which can be used as a 'bridge to transplantation' to provide temporary circulatory support while waiting for a suitable donor heart to become available. These devices are most commonly placed in the left ventricle but can be fitted to the right or both ventricles. VADs can also be used to provide longer term circulatory support and in some cases allow the heart to recover without the need for a transplant. Another 'bridge to transplantation' method is the implantation of a total artificial heart powered by a portable 'driver' which is carried in a backpack or shoulder bag. This involves removal of some parts of the heart and aims to improve the person's condition before transplant.

Conventional heart transplantation involves removing the heart of a donor after brainstem death, from someone who has permanently lost the potential for consciousness and the capacity to breathe on their own. There is a limited number of post-brainstem death donors worldwide, but using DCD hearts could increase the number of hearts for transplantation by more than 10% ([Knop et al. 2016](#)). Heart transplantation following circulatory death is not routinely recommended clinical practice in the UK (British Transplantation Society guidelines on [transplantation from deceased donors after](#)

circulatory death, 2013).

A donor heart for transplantation is usually preserved using cold ischaemic storage. A cardioplegia solution is used to stop the heart, which is then placed in a sealed bag immersed in preservation solution and packed in ice. Finally, it is transported in a non-sterile insulated box from the donor site to the recipient. The maximum recommended preservation time for donor hearts is 6 hours (Hicks et al. 2014, Hosgood et al. 2014).

NICE interventional procedure guidance on normothermic extracorporeal preservation of hearts for transplantation following donation after brainstem death states that this technology has sufficient short-term safety evidence to support its use with normal arrangements for clinical governance and audit. The guidance does not include recommendations on the procedure for preserving hearts explanted after circulatory death.

Population, setting and intended user

Adults or children needing heart transplants are typically those with severe heart failure for whom medical treatment with drugs, pacemakers, or revascularisation, has not worked. Heart failure can be caused by a number of factors including coronary heart disease, cardiomyopathy, valve disease or congenital heart defects.

The OCS Heart system can be used to preserve hearts for donation after either circulatory or brainstem death. The OCS Heart system would be used by qualified healthcare professionals specialising in heart transplantation and trained in the use of the OCS Heart system. The technology would be used in specialist transplant centres in the NHS.

Costs

Device costs

The cost of the single-use OCS Heart Perfusion Set is about £30,000 and the approximate cost of the reusable OCS Heart console is £180,000.

The manufacturer reports that the estimated lifespan of the main components of the technology (OCS Heart console) is 3,000 hours of active use, which equates to a conservative estimate of 10 years for each NHS centre's heart transplant workload.

Around 200 heart transplants are done in the UK every year (BHF, 2016). There are 6 NHS heart transplant centres and 1 additional NHS children's hospital with a heart transplant centre (NHS, 2016). Therefore, the heart transplant caseload per centre is estimated to be around 29 per year. Taking account of the transplant consumable costs (OCS Heart Perfusion Set) and using the annuity method with a discount rate of 3.5%, the estimated (technology only) cost per transplant would be £30,758. It should be noted that this cost estimate only includes equipment costs and does not account for different rates of use or possible long-term resource consequences.

Costs of standard care

Cold ischaemic or static storage is currently used for donor heart preservation after brainstem death in the NHS. The cost of cold storing organs includes the cost of disposable consumables and the solutions in which organs are stored. A health technology assessment report comparing storage methods for kidneys states that the NHS buys generic transplant consumables together (including sterile plastic bags and a non-sterile insulated box for storage and transportation) at £45.80 per box (Bond et al. 2009). The specialist commentators for this briefing felt that this is comparable to the cost for donor heart storage. One specialist stated that their centre pays about £70 for each non-sterile insulated box to transport the heart, and about £28.80 for the saline and plastic bags. The specialists noted that St Thomas' solution for cardioplegia is used for the preservation of donor hearts for transplant and this costs about £10 per litre, with each heart using 1.0 to 1.5 litres.

Resource consequences

According to the manufacturer the OCS Heart system is currently used in 3 NHS heart transplant centres and is being introduced in a fourth.

The OCS Heart system would not need additional facilities or technologies compared with cold ischaemic storage.

The manufacturer specifies that all relevant staff (surgeons, other clinicians and technical staff) must attend a 2-day training course before using the system. This training is included in the cost of the system. Annual maintenance of the OCS Heart system is needed and is provided free of charge by the manufacturer. No other practical issues have been identified in using the technology and no changes would be needed to the care pathway after transplantation.

No published evidence on the resource consequences of adopting the OCS Heart system was identified in the systematic review. No published papers relating to cost directly compared the OCS Heart system with standard care.

Regulatory information

The OCS Heart system was originally CE marked as a class IIa device in September 2006 and updated in February 2015.

A search of the Medicines and Healthcare Products Regulatory Agency website revealed that no manufacturer Field Safety Notices or Medical Device Alerts have been issued for this technology.

Equality considerations

NICE is committed to promoting equality, eliminating unlawful discrimination and fostering good relations between people with particular protected characteristics and others. In producing guidance and advice, NICE aims to comply fully with all legal obligations to: promote race and disability equality and equality of opportunity between men and women, eliminate unlawful discrimination on grounds of race, disability, age, sex, gender reassignment, marriage and civil partnership, pregnancy and maternity (including women post-delivery), sexual orientation, and religion or belief (these are protected characteristics under the Equality Act 2010).

People with heart failure may be considered to be disabled under the Equality Act if the condition has a substantial and long-term adverse effect on the ability to carry out normal day-to-day activities. Disability is a protected characteristic defined in the Equality Act 2010.

Clinical and technical evidence

A literature search was done for this briefing in accordance with the published process and methods statement. This briefing includes the most relevant/best publicly-available evidence relating to the clinical and cost effectiveness of the technology. The literature search strategy, evidence selection methods and detailed data extraction tables are available on request by contacting mibs@nice.org.uk.

Published evidence

Five studies including a total of 158 heart transplants were selected for inclusion and are summarised in this briefing

Evidence on the use of the OCS Heart system following donation after brainstem death published before December 2015 (including evidence from [PROCEED II](#), a prospective, randomised controlled trial by [Ardehali et al. 2015](#)) is summarised in NICE interventional procedure guidance on [normothermic extracorporeal preservation of hearts for transplantation following donation after brainstem death](#), and therefore has not been included in this briefing. No studies published before December 2015 examined the use of the OCS Heart system following donation after circulatory death. The guidance concludes that the OCS Heart system can extend heart preservation times compared to cold storage, for hearts donated after brainstem death.

Two studies reported as abstracts compared patient survival after transplant using the OCS Heart system compared with cold storage preservation. One of these studies reported 2-year patient survival ([Esmailian et al. 2016](#)) and the other reported 30-day survival in patients who had left ventricular assist device treatment as a bridge to transplant ([Garcia Saez et al. 2015](#)).

Two non-comparative studies reported 2- and 4-year patient survival of people given donor hearts with extended transplantation time or extended donor criteria (donors with 1 or more risk factors; [Garcia Saez et al. 2016](#) and [Yeter et al. 2014](#)). One full publication ([Messer et al. 2016](#)) looked at the use of the OCS Heart system for functional assessment and transplantation of donor hearts after circulatory death. Overall, no adverse events were reported and the OCS Heart system was found to have similar survival at 30 days and 2 years in comparison with cold ischaemic storage preservation for donation after brainstem death.

[Table 1](#) summarises the clinical evidence as well as its strengths and limitations.

Strengths and limitations of the evidence

Two out of 5 studies were done outside of the UK. Operative and post-operative practices may vary in different countries, which may affect patient outcomes and the generalisability of these studies to the NHS.

Four studies were conference abstracts and therefore lacked detail on methodology. They did not report a sample size calculation and it is unclear whether they were adequately powered to detect differences in outcomes.

One study ([Esmailian et al. 2016](#)) used a subset of patients from [PROCEED II](#), included in NICE's interventional procedure guidance on [normothermic extracorporeal preservation of hearts for transplantation following donation after brainstem death](#) to assess 2-year outcomes including survival and non-fatal major cardiac events.

Table 1: Summary of selected studies

Study size, design and location	Intervention and comparator(s)	Outcomes	Strengths and limitations
Esmailian et al. (2016) 38 patients RCT Single-centre USA	The Organ Class System Heart (OCS) (n=19) compared with standard cold storage (n=19).	There was no significant difference in the 2-year outcomes (patient survival rate, cardiac allograft vasculopathy, any-treated rejection, biopsy-proven cellular rejection, biopsy-proven antibody-mediated rejection or non-fatal major cardiac events) between the OCS group and the cold storage group.	This study used data from PROCEED II , which provided a randomised controlled trial (RCT) comparison of OCS with cold storage.

<p><u>Garcia Saez et al. (2016)</u> 60 patients Prospective observational study Single-centre UK</p>	<p>OCS in standard criteria donors (n=24) and extended criteria donors, defined as having at least 1 risk factor from the following (n=36): left ventricular ejection fraction < 50%, left ventricular hypertrophy, interventricular septum in diastole > 14 mm, donor cardiac arrest, coronary artery disease, known cocaine abuse or circulatory death (DCD).</p>	<p>Heart recipients were comparable in both groups. Transport time was ≥ 2.5 hours in 26 donors. One-month, 1-year, and 2-year survival were similar between the two groups.</p>	<p>This was a prospective observational study with long-term survival data (2 years), but there was no-comparative intervention.</p>
<p><u>Messer et al. (2016)</u> 13 patients Prospective non-comparative feasibility and clinical phase study Single-centre UK</p>	<p>Adult DCD donors.</p>	<p>Four hearts were assessed in the feasibility phase and 2 were deemed unsuitable for transplantation after functional assessment. Nine DCD hearts were transplanted in the clinical phase with 100% patient and heart survival. There were no episodes of rejection (total of 1436 patient days, range 48-297 days).</p>	<p>The study had limited follow-up time.</p>

<p><u>Garcia Saez et al. (2015)</u>, 30 patients Retrospective study Single-centre UK</p>	<p>Continuous flow left ventricular assist device (LVAD) transplant with grafts preserved with OCS (n=15) compared with cold storage preservation (n=15).</p>	<p>Patient survival at 30 days was significantly better in patients whose donor heart was in the OCS group in comparison with the cold storage preservation group.</p>	<p>The study is limited in that it was retrospective and provided shorter-term outcomes (30-day survival). The study was done in a subgroup population of LVAD bridge-to-transplant patients which means it may not be generalisable to all heart transplant patients.</p>
<p><u>Yeter et al. (2014)</u>, 21 donor hearts Unclear study design Single-centre Germany</p>	<p>OCS (no comparator) in cases of extended organ transportation time and extended donor criteria.</p>	<p>The median time the heart spent ex-vivo was 388 minutes. There was a high rate of freedom from cardiac related death at 30 days and 6 months (95%). This was slightly lower at 1 year and 4 years (87%).</p>	<p>The study provided data on long-term survival (4 years), but the study design is unclear and it lacked comparison with cold storage preservation.</p>

Recent and ongoing studies

One ongoing trial using the OCS Heart system were identified in the preparation of this briefing.

- [NCT02323321](https://clinicaltrials.gov/ct2/show/study/NCT02323321) (EXPANDHeart): a US-based, interventional efficacy study to determine the effectiveness of the OCS Heart system to preserve donor hearts that may not meet current standard donor heart acceptance criteria for transplant. This is an ongoing study with estimated study completion date in November 2017.

Specialist commentator comments

Comments on this technology were invited from clinical experts working in the field and relevant patient organisations. The comments received are individual opinions and do not represent NICE's view.

All 4 specialist commentators were familiar with the OCS Heart system and 2 have used this technology. Two of the commentators (from the same hospital) were involved in clinical trials of the device.

Level of innovation

The specialist commentators considered the OCS Heart system to be a major variation on current clinical practice with a novel design and concept. It has the potential to improve outcomes for heart transplantation compared with cold ischaemic storage. Training is necessary and clinicians must learn how to place hearts in the OCS Heart system effectively and safely, as well as how to manage and interpret the data given before deciding whether to proceed to recipient implantation. Regular use of the device is needed to develop experience and maintain skills.

Potential patient impact

The commentators felt that the OCS Heart system is unique, in that it allows hearts to be donated from donors after circulatory death. This is a novel concept for increasing the number of hearts for transplantation, which were previously only available for donation after brainstem death. One specialist speculated that if made available across the UK, heart retrieval after circulatory death could potentially increase annual UK heart transplant activity by 30% to 40%. Increasing the number of donor hearts would reduce the average waiting time for patients. It may also reduce hospital admission rates for decompensation (functional deterioration of the heart), and waiting list mortality.

The commentator added that hearts that are considered to have extended donor criteria can be assessed by the OCS Heart system before deciding whether or not to proceed to implantation.

Heart recipients needing a complex operation to remove their own heart (for example, those with complex congenital heart disease or needing left ventricular assist device

[LVAD] explant) may be more likely to need longer surgery. The OCS Heart system allows the donor heart to be moved to the recipient hospital and remain on the system until the recipient heart has been explanted, without further ischaemic time. Additionally, the OCS Heart system allows donor hearts to be transported from further away, with transport times that would be too long for standard cold storage. The specialist therefore suggested that the system could allow heart transplantation to become a planned urgent procedure rather than an emergency.

One specialist commentator stated that in their opinion the OCS Heart system offers improved outcomes through a reduction in primary graft dysfunction, although there is no published evidence to support this currently. One specialist reflected that the OCS Heart system has the potential to expand the number of suitable donors, increase the likelihood of heart transplantation, decrease waiting times and potentially reduce mortality rates of people on the waiting list.

Potential system impact

In increasing the range of donor hearts available, the OCS Heart system could increase the number of heart transplants done in the NHS. This could affect staffing and theatre time (as the OCS Heart system needs more team members present for retrieval), bed usage and post-transplant follow-up. These factors may have an impact on workforce, rotas, and costs as well as on other services which may be displaced because of the urgent nature of heart transplantation.

Two specialists suggested that if the rates of heart transplant were increased there may be a decrease in the number of LVADs used as a bridge to heart transplant, with consequent cost savings. One specialist pointed out that this would not result in a one-to-one ratio between the number of extra transplants and the avoidance of LVADs. One commentator stated that there may be a significant cost reduction for the perfusion set if it is bought in bulk.

Use of the OCS Heart system has potential for cost savings by allowing more hearts to become available and reducing overall waiting times, thus limiting prolonged and recurrent hospital admissions associated with heart failure and in-hospital waits.

General comments

One specialist highlighted that the OCS Heart system cannot be used for many paediatric patients. Two specialists stated that the technology is invaluable in special circumstances, such as heart transplantation after circulatory death. However one commentator noted that this technology is very expensive and therefore more evidence of patient benefit is needed before it could be considered for routine use.

Specialist commentators

The following clinicians contributed to this briefing:

- Dr Clive Lewis, Consultant Cardiologist and Transplant Physician, Papworth Hospital, no conflicts of interest declared.
- Mr Steven Tsui, Consultant Cardiothoracic Surgeon & Director of Transplant Service, Papworth Hospital, no conflicts of interest declared.
- Dr Jayan Parameshwar, Consultant Cardiologist, Papworth Hospital, no conflicts of interest declared.
- Dr Sern Lim, Consultant Cardiologist, Queen Elizabeth Hospital Birmingham, no conflicts of interest declared.

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