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Total artificial hearts

Are total artificial hearts a solution to late-stage heart failure, or are they just complicated ventricular assist devices?

What are total artificial hearts?

With a lack of donor organs, the concept of keeping hearts beating through mechanical devices has attracted attention for decades. Total artificial hearts (TAHs) are replacement devices that mimic the human heart. TAHs are permanent devices that are the aspirational endpoint of this approach to cardiovascular failure.

The only TAH available today (marketed by its designer SynCardia in the US) works similarly to a ventricular assist device (VAD) and is used as a bridge to implantation for patients waiting for a donor heart.

However, several companies are making strides towards perfecting a fully actualised permanent heart as a destination therapy and alternative to donor transplant, the first of which might be on the market as early as 2020.

How do TAHs differ from VADs?

VADs are similar in some ways to TAHs, helping pump blood through the body by assisting the ventricles of the heart.

VADs can be either attached to the left (LVAD) or right ventricle of the heart. If VADs are used on both ventricles, they are known as a biventricular assist device (BIVAD).

A crucial difference between a VAD and TAH is that VADs are assistive devices. As a result, the heart's ventricles remain intact. The rest of the heart should therefore be somewhat healthy for VAD implantation, which is often not the case.

Despite this, the market penetration was such that LVAD manufacturers Thoratec and Heartware were both acquired by major medical device companies in 2015 and 2016 respectively.

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'In August, Carmat announced the completion of the first successful donor heart transplant of a patient previously implanted with the Carmat TAH in October 2017. For eight months, the Carmat TAH supported the patient, who was in end stage heart failure and previously ineligible for a heart transplant due to pulmonary hypertension. Maxim Jacobs, Healthcare Analyst

What are the risks of investing in artificial hearts?

The viability of TAHs depends on successful outcomes in clinical trials. Although there have been positive early results in bovine and human studies for most clinical TAHs, unforeseen malfunctions could slow down development and increase the cost of getting them to market.

The successful commercialisation of new TAHs also depends on the development of new specialist centres for implantation, as well as the companies' ability to engage with the medical community.

Even with successful implementation of specialist centres and engagement with key opinion leaders, it is not known how quickly the medical community will adopt TAHs as a replacement for donor hearts and VADs.

Regulatory hurdles such as the Premarket Approval Application (PMA) and humanitarian-use device (HUD) requirements may also limit the potential target market for artificial hearts or slow the development process. In addition, the scale-up of manufacturing can be a challenge when requirements for high-quality standards and materials are a prerequisite of production.

What are the regulatory requirements for TAHs?

As medical devices, TAHs must complete a PMA in the US or have a CE mark from the European Medicines Agency.

In both regulatory domains, devices are ranked Class I, II and III. Class I products are mostly non-evasive low-risk devices that require much less clinical evidence than Class III devices, TAHs included.

In the US, TAHs have to go through a PMA process or list as an HUD.

HUD requirements require less clinical data for commercialisation but limit the

product as a device intended to benefit no more than 8,000 individuals, which significantly reduces the target market.

The PMA process is more onerous, requiring rigorous efficacy data that take significant time and money to produce, but it opens a larger market.

Which companies are investing in artificial hearts?

SynCardia's device is the only approved TAH on the market, with more than 1,700 implants worldwide. However, it has PMA approval in the US alone and is a bridge-to-transplant device only, although the company is conducting clinical trials in destination therapies and with a 50cc smaller heart for paediatric care and smaller adults.

Two other companies are developing TAHs for use in long-term therapy. BiVACOR is developing a centrifugal rotary pump-based TAH, which applies magnetic levitation to a single moving part to reduce mechanical wear and ensure the device's long lifespan.

Carmat's TAH is arguably the closest to market in the EU, with a CE mark expected in 2020. However, it recently had to halt manufacturing to improve the process; production has now resumed. In the first cohort of 10 patients from its EU pivotal study, 70% of patients were alive six months post-transplant.