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Lifebridge B²T – a Heart Lung Machine

M. Krane, D. Mazzitelli, B. Voss, R. Lange, R. Bauernschmitt

■ Summary

The use of cardiopulmonary bypass systems in patients undergoing emergency circulatory resuscitation was limited by the large size and complicated setup of currently available systems. The LIFEBRIDGE B²T-system is a new portable circulatory support system consisting of a disposable patient unit with a cardiopulmonary bypass circuit, a control unit, and a base unit with user interface. The portability of the system (17 kg, with a 2.5-hour LiPo battery capacity), as well as the simplicity of application (semi-automatic priming procedure and air elimination), is designed to address these concerns and allow for mobile mechanical circulatory support in a variety of situations and settings. In our first experience, we found the LIFEBRIDGE B²T-system to be safe and easy to use even for trained non-perfusionists and worthy of further investigation in surgical and non-surgical settings.

■ Introduction

Cardiopulmonary bypass has been well established as the standard for maintaining cardiac and pulmonary function in patients undergoing different procedures in cardiac surgery [1]. Over the past decade, mechanical circulatory support (MCS) systems have been modified for various indications resulted in improved mortality, including bridge to transplant or bridge to recovery. Despite these improvements, there has been little application for MCS in patients undergoing emergency circulatory resuscitation, most likely due to the large size and complicated setup of currently available systems.

Cardiogenic shock due to myocardial infarction is still associated with a high mortality of more than 60 % [2]. Early treatment of patients in low cardiac output with an extracorporeal circulatory support system could prevent multi organ failure and reduce the high mortality-rate in these patients.

LIFEBRIDGE® Medizintechnik AG, Ampfing, Germany has developed a portable, modular, rapidly available “plug and play” mechanical circulatory support system called the LIFEBRIDGE B²T®-system, which is designed to address the need for full MCS in mobile as well as in standard situations [3, 4]. This report reflects our first experience utilizing the LIFEBRIDGE B²T®-system for circulatory support during beating heart coronary artery bypass surgery.

■ Lifebridge B²T

The LIFEBRIDGE B²T (Fig. 1) is a modular emergency system for circulatory support characterized by the following features: modular configuration and semi-automatic priming, portability including integrated power supply offering up to two hours of stand-alone operation with LiPo batteries, and a seven stage air infusion prevention system which can tolerate

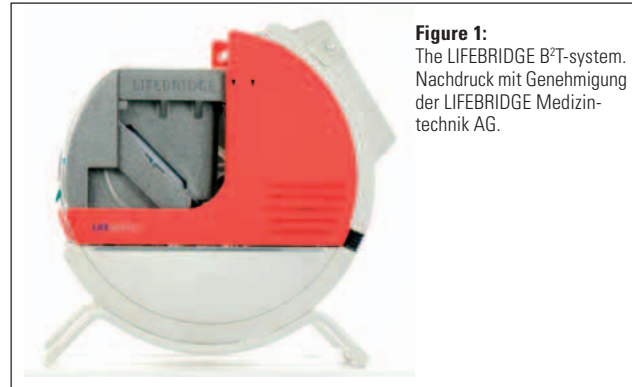


Figure 1:
The LIFEBRIDGE B²T-system.
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technik AG.

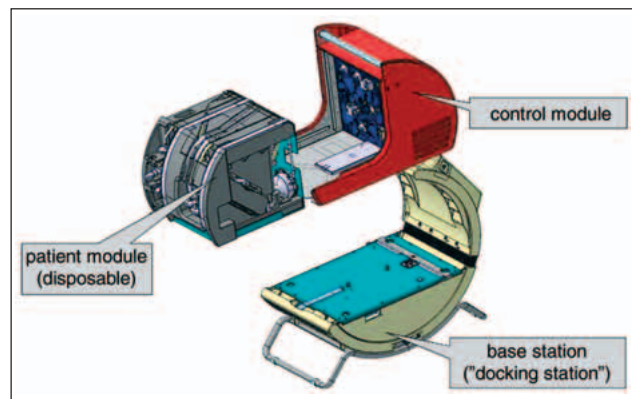


Figure 2: The modular setup of the LIFEBRIDGE B²T. Nachdruck mit Genehmigung der LIFEBRIDGE Medizintechnik AG.

massive venous ingress of air without jeopardizing patient safety. The system consists of three modules (Fig. 2).

Patient Module (PM)

The PM is the disposable part of the system representing a standardized extracorporeal circulation. The PM consists of a venous reservoir, a centrifugal blood pump, an oxygenator and an arterial filter. All components and the majority of tubing are fixed in molded parts made of expanded polypropylene. This provides excellent protection against external influences. Sensors used for pressure monitoring and flow level sensing are also integrated into the PM.

Control Module (CM)

The CM contains all active parts necessary to drive and control the extracorporeal circulation. This includes the motor of the blood pump, a roller pump for air elimination and automatic clamps affecting the blood flow. Additional sensors for bubble detection and level sensing are incorporated to control system function and air elimination processes. The integrated backup battery allows stand-alone operation of the CM and PM for up to 30 minutes. In general, the CM is the non-dispos-

able part of the system, excluding the user interface and the main power supply.

Base Module (BM)

The BM, with its tubular frame, provides tilt-resistant standing of the LIFEBRIDGE B²T. It contains the main power supply and an embedded portable computer (EPC) with connected touch sensitive flat panel and rotary switch, forming the user interface. In addition to the 30 minute battery capacity of the CM, the BM also provides 2 additional hours of battery capacity, thus bringing the total capacity to 2.5 hours. Finally, the BM implements pivot mounting used to rotate the CM and PM by 90° during the semiautomatic priming procedure, ensuring a secure elimination of air from the cardiopulmonary bypass circuit.

Extracorporeal circuit

The LIFEBRIDGE B²T is a closed system avoiding air blood contact. The LIFEBRIDGE B²T is attached to an arterial and venous blood vessel of the patient via an arterial and a venous cannula. The centrifugal blood pump is preceded by a venous reservoir. The blood pump is followed by an oxygenator and an arterial blood filter. A bubble detector is placed right behind the arterial filter. Air detection at this point triggers the “Air Management” protocol. During this procedure the arterial line is closed first, with an arterial quick-closing clamp assuring short closing times of less than 300 ms. By opening an arterio-venous shunt, the detected air is eliminated directly to the venous reservoir. When no more air is detected, the “Air Management” procedure concludes after a few seconds with the closing of the shunt and re-opening of the arterial line. A schematic drawing of the extracorporeal circuit is illustrated in Figure 3.

■ Patients

The use of the LIFEBRIDGE B²T for circulatory support was approved by the ethical committee of the Technische Universität München.

We used the LIFEBRIDGE B²T-system in a patient who underwent beating heart coronary artery bypass surgery for complete revascularization. The patient was placed on mechanical circulatory support during the procedure due to hemodynamic instabilities at the beginning of off-pump coronary artery bypass surgery. Connection to LIFEBRIDGE B²T was achieved via percutaneous cannulation of the femoral artery (Fig. 4) and the femoral vein utilizing a 24F cannula (Edwards Lifesciences) for venous blood drainage and an 18F cannula (Edwards Lifesciences) for arterial cannulation. The patient underwent successful beating heart coronary artery bypass surgery with complete revascularisation. Semi-automatic priming of the system was achieved in 5–10 minutes. No technical problems occurred during the use of the MCS system LIFEBRIDGE® B²T. The target blood flow for the patient was 5.1 l/min. During circulatory support the system delivered a mean arterial blood flow of 4.4 ± 0.42 l/min (range: 3.5–5.1 l/min). Mean negative pressure at the venous drainage was -94.4 ± 30.4 mmHg (range: -45 to -126 mmHg) and

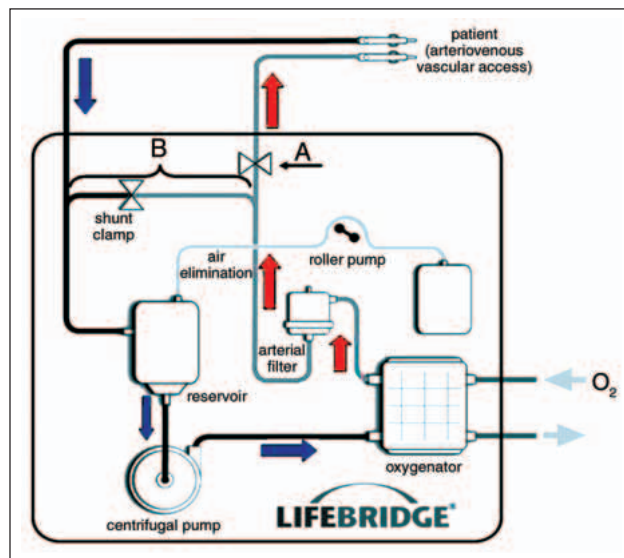


Figure 3: Extracorporeal circuit of the LIFEBRIDGE B²T. A: arterial fast clamp; B: arterio-venous shunt for air-elimination. Nachdruck mit Genehmigung der LIFEBRIDGE Medizintechnik AG.



Figure 4: Percutaneous cannulation of the femoral artery and femoral vein

mean arterial pressure during circulatory support was 68 ± 6 mmHg (range: 50–74 mmHg). The maximum concentration of free haemoglobin during and after the procedure was 10 mg/dl 2 hours after extracorporeal circulation.

■ Discussion

Early experience with the LIFEBRIDGE B²T has shown it to be a feasible alternative to standard extracorporeal circulation in support of beating heart coronary artery bypass surgery. During the procedure the LIFEBRIDGE B²T delivered a blood flow of 4.4 ± 0.42 l/min via percutaneous cannulation, which was close to the calculated blood flow of 5.1 l/min. The system provides an adequate arterial pressure, an acceptable negative pressure at the venous cannula and only a moderate haemolysis.

Percutaneous cannulation (18F arterial/ 24F venous) was performed without any complications. There were no signs of leg ischemia or bleeding complications during and after the operation.

Table 1: Possible indications for mechanical circulatory support with the LIFEBRIDGE B²T-system

- Circulatory support of patients in cardiogenic shock during transport/diagnostic
- Circulatory support during high risk PCI
- Back up/ circulatory support during transcatheter aortic valve implantation
- Circulatory support in patients with fulminant pulmonary embolism
- Rewarming/circulatory support in patients with hypothermia
- Circulatory support during beating heart coronary artery bypass grafting

Further research is in progress to develop an automated patient adapted perfusion mode. This could improve the safety of the system during mechanical circulatory support, especially when the system is used by trained non-perfusionists.

In the future, the “plug and play” aspects of the system will make it easy to use for perfusionists and trained non-perfusionists alike. The system’s semi-automatic priming system, automated air elimination protocol and lightweight portability

will make the LIFEBRIDGE® B²T-system suitable for use during emergency transport as well as standard surgical or non-surgical procedures. Table 1 summarised possible indications for mechanical circulatory support with the LIFEBRIDGE® B²T.

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