A New Option for Short- or Long-Term Peripheral Access to the Central Venous System

A product technology overview of the BioFlo™ PICC with Endexo™ Technology, with and without PASV™ Valve Technology

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Peripherally inserted central catheters (PICCs) are increasingly utilized as an alternative to central venous catheters due to improved patient comfort, overall reliability, and the ability of the PICCs to be inserted bedside by nurses.1 Along with this increase in PICC usage has surfaced heightened attention on catheter-related thrombus (CRT). Complications associated with CRT may include catheter dysfunction, infection, loss of central venous flow or upper extremity deep vein thrombosis (UEDVT).2 Additionally, significant risk potential exists in the form of pulmonary embolism associated with UEDVT. The incidence of catheter-related thrombosis for central catheters has been reported as 2% to 67%.3 Specific to peripherally inserted central catheters, venous thrombosis rates of 27% have been reported by Bonizzoli et al in critically ill patients.1 Based on the significance of the issue and potential complications, the prevention or reduction of catheter-related thrombus continues to be of concentrated clinical focus.

Catheter-related thrombus results from the interaction of the patient characteristics (inherited and acquired risk factors) and the indwelling catheter.3 The underlying patient condition, such as malignancy of immobility, promotes the hypercoagulable state which creates an intravascular environment with increased thrombus potential.4,5 The indwelling catheter contribution to thrombus may be both acute and chronic in nature. Acute contributions to thrombus may include the body’s response to vascular trauma via complement activation or other means due to venipuncture, introduction of indwelling catheter, or vascular trauma caused by catheter motion during power injection as recently reported in the literature.6 The subacute to chronic contributions of the catheter to CRT include tip location, vessel trauma, insertion site, and catheter design parameters inclusive of the following: number of lumens, size/profile of the catheter (including reverse taper), materials of construction, and catheter surface/bulk characteristics.3,7 Improved patient characteristics, enhanced catheter properties or a combination thereof are understood to reduce the potential for catheter-related thrombus.

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THE BIOFLO PICC TOTAL CATHETER PERFORMANCE

In consideration of the mechanism for thrombus adherence on an indwelling device, the BioFlo PICC was designed around the fundamental clinical premise: if a catheter material does not allow blood components to adhere, then it will reduce thrombus accumulation on the catheter. The result is the BioFlo PICC with Endexo Technology (“BioFlo PICC” or “BioFlo device”), an innovative peripherally inserted central catheter possessing a durable thromboresistant character. The catheter is constructed of a proprietary polymer blend of Carbothane® thermoplastic polyurethane and Endexo polymer, a permanent and non-eluting polymer. The combined material imparts the catheter shaft with protection against thrombus accumulation by creating passive surfaces. The BioFlo device (Figure 1) is also available with the PASV Valve (Pressure Activated Safety Valve), a proximal valve designed to reduce the blood reflux that leads to catheter-related complications.

The BioFlo PICC is designed for Total Catheter Performance, including the catheter shaft having a short reverse taper which allows for optimal catheter size in the vessel while providing a taper to staunch blood loss at the insertion site. Other attributes include stability during power injection, alcohol-resistant polyurethane material for insertion site care, and compatibility with chemical infusates including chemotherapy and vesicants. These characteristics in combination with the non-eluting, durable thromboresistant material result in the Total Catheter Performance of the BioFlo PICC. The BioFlo PICC is commercially available and has intended use for short- or long-term peripheral access to the central venous system for intravenous therapy, including but not limited to the administration of fluids, medications and nutrients, the sampling of blood, for central venous pressure monitoring (non-valved versions) and for power injection of contrast media.
THE BIOFLO TECHNOLOGY

The BioFlo technology’s thromboresistant character is achieved by intimately combining the Endexo polymer with the base Carbothane polymer via thermoplastic extrusion processes. Unlike coatings that are superficial and impregnated agents that are transient, the BioFlo technology is an integral, non-eluting polymer technology that imparts thromboresistant properties to the indwelling catheter (Figure 2).

The "non-stick" characteristics of the BioFlo material and resultant catheter construction reduce the adherence of blood components, such as platelets and thrombus†. Not containing heparin, the BioFlo technology may help to minimize complications associated with heparin. Additionally, the BioFlo PICC does not contain antibiotics or antimicrobial agents, aiding to reduce potential complications associated with bacterial resistance. The BioFlo technology is throughout the catheter material (inside, outside and cut surfaces) and remains for the life of the device. In fact, the exposure of the BioFlo PICC to simulated implant flow conditions (i.e. temperature, flow, pH, time) demonstrated that the Endexo polymer concentration within the BioFlo PICC did not degrade or change over extended durations (Figure 3).

THE PASV TECHNOLOGY

The BioFlo PICC is also available with the PASV valve technology (Figure 4). The Pressure Activated Safety Valve is a proximal valve located on the external portion of the catheter designed to replace manual clamps and their associated limitations. During infusion, the valve opens with minimal pressure and automatically closes after use. Under aspiration, the valve opens for sampling and automatically closes. When not in use, the PASV valve remains closed during normal increases in central venous pressure to prevent reflux which may lead to catheter complications. The PASV valve, designed for ease of infusion and prevention of blood reflux into the lumen, has a robust clinical history of over 12 years.

![Figure 2. Comparison of BioFlo to Other Technologies](image)

![Figure 3. Endexo Concentration with Extended Fluid Flow Exposure](image)

![Figure 4. PASV Valve Operation](image)
IN-VIVO AND IN-VITRO PICC
THROMBORESISTANCE EXPERIENCE

Critical to the performance of the BioFlo PICC is the thromboresistant character on the catheter shaft. Experience in in-vitro and in-vivo settings has clearly demonstrated that the BioFlo PICC is effective at reducing thrombus accumulation on the indwelling device without having persistent systemic impact. Reported herein are pertinent results from an in-vitro blood loop, an in-vivo ovine study, and in-vivo rabbit studies.

To quantify the thromboresistance of the BioFlo PICC, a well-established method for characterizing the thromboresistant character of medical devices and material was utilized. This test, commonly known as the Blood Loop, utilizes freshly harvested bovine blood to quantify platelet and thrombus adherence on the test samples. Once harvested, the platelets are radiolabeled to enable measurement and quantification. The blood is then loaded into a number of test circuits and circulated over the specimens in a controlled environment employing clinically relevant parameters for such items as temperature and flow rate. Providing a direct comparison of test versus control articles, this accelerated test runs for up to two hours, with both qualitative and quantitative evaluation made for thrombus accumulation on the devices. During the direct comparison in thirteen discrete animal blood lots, the BioFlo PICC demonstrated on average 87% less thrombus accumulation on its surface compared to commonly used PICCs (Figure 5).

With the BioFlo PICC evaluated against conventional PICCs and demonstrating a significant reduction in thrombus accumulation on the catheter, an ovine (sheep) study was conducted under good laboratory practices (GLP) to compare the BioFlo PICC to a FDA 510(k) cleared heparin-coated intravascular device possessing specific thrombus reduction claim. This sheep study included the percutaneous bilateral implantation of both test and control articles in twelve animals, with implant side randomized. Including two cohorts at 14 and 31 day indwelling, all animals were subjected to a comprehensive necropsy focused on macroscopic evaluation of the outer surface of the in-dwelling catheter for adherent material. Results demonstrated that during both 14 and 31 day indwelling times in an ovine model the BioFlo PICC’s thromboresistance was generally comparable to a positive control heparin-coated catheter (Figure 6).

Additional pre-clinical studies were conducted to support the overall safety profile of the BioFlo PICC and to complement the extensive biocompatibility testing conducted for a long-term intravascular catheter. A total of sixteen rabbits had either the BioFlo PICC or a control catheter randomly implanted in the jugular vein. The study evaluated the systemic effect of the BioFlo PICC compared to a conventional control to objectively demonstrate that the addition of the thromboresistant character did not have any differing immunogenic impact as determined by such measures as complement activation, total protein levels, fibrinogen levels, and Activated Partial Thromboplastin Time (APTT). All measures, including the APTT results summarized in Figure 7, indicated no alteration of immune system function, protein deposition or sub-chronic toxicity.

CONCLUSIONS

The BioFlo PICC represents a differentiated product, in a market offering redundant technologies, in the form of the BioFlo material and the PASV valve, both designed to address catheter complications. The in-vitro and in-vivo experience with the BioFlo PICC confirms that the innovative polymer technology is effective at reducing thrombus accumulation on the catheter. On average results have demonstrated an 87% reduction in thrombus accumulation on its surface compared to commonly used PICCs and comparable performance to a heparin-coated thromboresistant vascular catheter while having no alteration to immune system function. Based on in-vitro and in-vivo animal testing, the BioFlo PICC is a durable technology possessing an effective, non-eluting thromboresistant benefit.
REFERENCES

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†The reduction of thrombus accumulation was evaluated using in-vitro and in-vivo models. Pre-clinical in-vitro and in-vivo evaluations do not necessarily predict clinical performance with respect to thrombus formation.

BIOFLO PICC WITH ENDEXO AND PASV VALVE TECHNOLOGY

INTENDED USE/INDICATIONS FOR USE: The BioFlo PICC with Endexo and PASV Valve Technology is indicated for short or long-term peripheral access to the central venous system for intravenous therapy, including but not limited to, the administration of fluids, medications and nutrients; the sampling of blood; and for power injection of contrast media.

CONTRAINDICATIONS: Venous thrombosis in any portion of the vein to be catheterized. Conditions that impede venous return from the extremity such as paralysis or lymphedema after mastectomy. Orthopedic or neurological conditions affecting the extremity. Anticipation or presence of dialysis grafts or other intraluminal devices. Hypercoagulopathy unless considerations are made to place the patient on anticoagulation therapy. Pre-existing skin surface or subsurface infection at or near the proposed catheter insertion site. Anatomical distortion of the veins from surgery, injury or trauma. Inadequate antecubital veins. Anatomical irregularities (structural or vascular) which may compromise catheter insertion or catheter care procedures.

WARNINGS: Due to the risk of exposure to bloodborne pathogens, care providers must adhere to guidelines for universal blood and bodily fluid precautions in the care of all patients. Sterile technique must be strictly adhered to during any handling of the device. Contents are supplied sterile by EO for single patient use only. Do not use if sterile barrier is damaged. Do not use if product has been damaged. Do not reuse, reprocess or resterilize, to do so may compromise device integrity and/or lead to device failure which in turn may result in patient injury, illness or death; and may also create a risk of contamination, patient infection or cross infection which may lead to injury, illness or death of the patient. Do not place the catheter into the right atrium or the right ventricle of the heart. Do not attempt to trim the catheter with the guidewire or stylet loaded as catheter, stylet, or guidewire may become damaged resulting in patient injury. Failure to warm contrast media to body temperature prior to power injection may result in catheter failure. Failure to ensure patency of the catheter prior to power injection studies may result in catheter failure. Power injectors' pressure limiting (safety cut-off) feature may not prevent over-pressurization of occluded catheter. Exceeding the maximum allowable flow rate (per the Directions for Use) may result in catheter failure and/or catheter tip displacement. Cather indication for power injection of contrast media implies the catheter's ability to withstand this procedure, but does not imply appropriateness of this procedure for a particular patient. A trained clinician is responsible for evaluating the health status of a patient as it pertains to a power injection procedure. The maximum pressure of power injectors used with the BioFlo PICC must not exceed 325 psi. For triple lumen catheters, only the purple lumen is for power injection. Do not use lumen marked “No CT” for power injection of contrast media as it may result in catheter damage or patient injury.

PRECAUTIONS: Do not insert the stiff end of the floppy-tipped guidewire into the vein. Acetone and polyethylene glycol-containing ointments should not be used with polyurethane catheters, as these may cause failure of the device. Following institutional policy, secure catheter externally to prevent catheter movement, migration, damage, kinking or occlusion. It is recommended that institutional protocols be considered for all aspects of catheter use consistent with the instructions provided herein including flushing of occluded catheters and power injection. The BioFlo PICC catheter testing included 10 power injection cycles. Use of a needle to access the catheter is not recommended. However, if a needle is used, do not use a needle longer than 1.9 cm as it may cause damage to the valve. Do not reinsert stylet into catheter, as damage to valve, catheter and vein may result. If a needleless connector is attached to catheter hub, first ensure that it will sustain power injection. When inserting a triple lumen catheter, the power injectable lumen must be used for guidewire/stylet placement.

Consult your AngioDynamics representative for country specific product availability.

www.angiodynamics.com
For more information, call 800.833.9973 in the United States 800.268.0184 in Canada

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