Millar®

Making the
improbable possible.

Millar Mikro-Tip®
Pressure-Volume Catheter

Intended for Non-Clinical Research Use Only
Animal Use Only

Instructions for Use

Table of Contents

Recommended Accessories

ADV500 Pressure-Volume Control System (Transonic Systems, Inc)
ADV550 Pressure-Volume Control System (Transonic Systems, Inc)

Definition of Symbols

	*Attention, Consult instructions for use*
	Date of Manufacture
	Catalog Number
	Serial Number
	Batch Code
	Use-by date
	Electrostatic Sensitive Device
	EU Declaration of Conformity
	UK Conformity Assessed
	Manufacturer

Device Description

Millar Small and Large Animal Mikro-Tip Pressure-Volume (P-V) catheters combine ultra-miniature pressure sensing technology and a series of electrodes mounted at various locations along the distal end of the catheter. The catheter terminates at a connector box at the proximal end. The pressure sensor produces an electrical output signal, which varies in direct proportion to the magnitude of sensed pressure. The electrodes allow for estimation of left and right ventricular volume changes and can be utilized in both conductance and admittance methods.

Millar Mikro-Tip P-V catheters are intended for multiple uses. Experience has proven that the instruments are safe and effective for extended service if proper handling, cleaning, and sterilization procedures are followed.

Immediately upon receipt of the catheter, and prior to its initial cleaning, sterilization, and use, the customer should verify that the catheter is operational.

Intended Use/Indications

Use of the Millar Mikro-Tip P-V catheter is indicated when combined physiological pressure and volume (as estimated by electrical impedance measurements) monitoring is required in small or large animal models.

Millar Mikro-Tip P-V catheters may be introduced into the left or right ventricle using a closed chest approach or using an open chest approach through an entry site made in the apex of the heart with a needle.

Proper catheter positioning within the left or right ventricle can be verified with the aid of echocardiography.

This product is designed for use by professionals with appropriate education and training in life science and medical research applications.

Warnings

- The Millar Mikro-Tip P-V catheter should be stored in a cool, dry place.
- For small animal catheters (≤2F) the Millar Mikro-Tip P-V catheter is shipped with a foam dome fitting over the catheter tip to protect the sensor/electrode area. The catheter tip should be left in the foam dome when the catheter is in the tray.
- For large animal catheters (5F) the Millar Mikro-Tip P-V catheter is shipped with plastic protective tubing over the pressure sensor. The protective tubing should be in place during handling.
- Do not allow any fluids to collect on the catheter connector.

Precautions

Proper handling of the Millar Mikro-Tip P-V catheter is critical to avoid damage and maximize the catheter's use-life.

- Use of the Millar Mikro-Tip P-V catheter should be restricted to specialists who are familiar with, and have been trained to perform, the catheterization procedures for which the device is intended.
- Do not under any circumstances bend, kink, fold, cut, pinch, crush, etc. the Millar Mikro-Tip P-V catheter especially around the sensor/electrode area. These actions could severely damage the catheter and/or render the catheter unusable and result in repair or replacement charges.
- The Millar Mikro-Tip P-V catheter should be inspected for damage (cracking, kinks, etc.) prior to each use.
- Do not grip the Millar Mikro-Tip P-V catheter with forceps, tweezers, or fingers anywhere near the sensor/electrode area.
- When using metal forceps or tweezers to grip the Millar Mikro-Tip P-V catheter, slip some soft tubing over the tips of the metal instrument to cushion the interface between the instrument and the catheter body and follow instructions on the Best Practices guide included with the catheter.
- Always grip the Millar Mikro-Tip P-V catheter proximal to the sensor/electrode area. Never grip the catheter between the electrodes or between the electrodes and the pressure sensor case.
- Always be mindful of the location of the catheter tip.
- Do not set heavy objects or metal instruments on top of the Millar Mikro-Tip P-V catheter.
- Do not tighten sutures over the sensor/electrode area on the Millar Mikro-Tip P-V catheter.

- When using the carotid artery approach in small animal models to insert the Millar Mikro-Tip P-V catheter into the left ventricle, advance the sensor/electrode area completely beyond the proximal suture before tightening the suture.
- When using the carotid artery approach in small animal models to insert the Millar Mikro-Tip P-V catheter into the left ventricle, take care not to damage the catheter with the tips of any forceps or tweezers that are used to grip the artery when inserting the catheter.
- When using the open chest approach in small animal models to insert the Millar Mikro-Tip P-V catheter into the left ventricle, do not push the catheter tip directly through the left ventricular wall. First, make an entry hole in the ventricular apex with a needle and then insert the catheter through the hole.
- Never apply excessive force when inserting the Millar Mikro-Tip P-V catheter. The catheter may incur damage and could puncture through the left ventricular wall or damage the aortic valve.
- If resistance is encountered while inserting the Millar Mikro-Tip P-V catheter, pull back slightly and then try advancing again.
- When removing the Millar Mikro-Tip P-V catheter through the carotid artery in small animal models, loosen the proximal suture before pulling the catheter out to ensure the pressure sensor or electrodes do not catch on the suture and lift or tear away from the catheter.
- The Millar Mikro-Tip P-V catheter should be cleaned immediately after each use (see Cleaning).
- Disconnect the Millar Mikro-Tip P-V catheter prior to defibrillation and electro surgery.
- The pressure sensor element on the Millar Mikro-Tip P-V catheter is sensitive to electrostatic discharge. Refrain from touching the sensor element while the catheter is not connected to monitoring equipment (see Best Practices and ESD Guidelines document).
- For large animal applications when the Millar Mikro-Tip P-V catheter is exposed to the vascular system, it should be manipulated while under high-quality fluoroscopic observation. If resistance is met during manipulation, determine the cause of the resistance before proceeding.
- Large animal Millar Mikro-Tip P-V catheters should be inserted or advanced via an introducer sheath or guide catheter. Pigtail extensions may fold or buckle if the catheter is advanced without an introducer.

Handling Precautions for Mikro-Tip P-V Catheters

	DO:	DO NOT:
Pressure Sensor & Electrodes	Clean immediately after use	Clean with stiff-bristled brush
		Clean with high pressure water jet
	Protect with dome or plastic tubing when not in use	Tap the sensor or electrodes against a rigid surface
	Disconnect during electrical defibrillation or electrosurgery	Apply excessive force to the sensor or electrodes
		Expose to excessive pressure
Catheter	Clean immediately after use	Cut, crease, knot, fold, kink, or crush with forceps or clamps of any kind
Connectors & Cables	Protect connectors from fluid	Immerse connectors in liquid
Cleaning	Keep catheter and sensor wet until cleaning	Expose to alcohol, cresols, phenols, mercury compounds, hypochlorites, acetone, peroxide, silicone chlorine, xylenes, trichloroethylene, or freon
	Clean thoroughly with approved enzymatic cleanser immediately after use	Use ultrasonic cleaner.
		Immerse electrical connector
Disinfection or Sterilization	Dry catheter before sterilizing	Sterilize by EtO, Autoclave, radiation (gamma/e-beam), plasma, peroxide or formaldehyde vapor solutions
	Remove plastic dome or tube from catheter	Use Sporox or Cidex PA solutions

Troubleshooting and Corrective Action

Problem	Probable Cause	Corrective Action
Excessive pressure signal drift	Deposit of foreign material on the diaphragm of the pressure sensor.	Follow Cleaning Instructions. If problem persists, contact Millar.
Pressure sensor will not balance (zero)	Moisture in the connector, damage to wires in the catheter, or fractured strain gauge within pressure sensor.	Follow Operating Instructions or substitute a transducer known to be operating properly into the recording system. If problem persists, contact Millar.
Noisy or erratic volume signal	Damage to electrodes or electrode-wire bond (“open electrode”).	Follow Operating Instructions or substitute a transducer known to be operating properly into the recording system. If problem persists, contact Millar.

Maintaining Device Effectiveness

Catheter Preparation

Presoak the catheter tip in saline or distilled water maintained at body temperature for at least 30 minutes prior to use. Only soak the catheter tip, do not submerge the catheter’s electrical connectors, as doing so will damage the sensitive electronics housed inside!

The presoak helps prepare the pressure sensor diaphragm for the "wet" biological environment. Presoaking the catheter tip in body temperature fluid also helps prevent pressure signal drift and negative pressure recordings. The presoak can be done by gently inserting the catheter tip into a beaker or dish or through the tip of a syringe.

Routine Inspection

CAUTION: If damage is found during inspection, DO NOT use the catheter. Contact Millar, LLC, or an authorized Millar distributor for assistance.

The Millar Mikro-Tip P-V catheter should be thoroughly inspected under magnification before and after each use to determine its condition. Carefully examine the catheter for cuts, kinks, or creases. The active surface of the sensor and electrodes should be examined for any film, blood, or biological debris that has not been removed by cleaning. Any film, blood, or biological debris may cause short-term baseline drift and should be removed. Such removal should consist of a thorough soaking in an enzymatic cleaning solution (Terg-A-Zyme®) followed by a persistent and gentle wiping action along the sensor or electrodes with a moist tissue, gauze, or cotton tipped swab. The connectors should undergo visual inspection for corrosion or bad contacts. Liquid entering the connector(s) can cause electrical hazard, erratic operation, and corrosion.

Pressure Calibration

Each transducer is calibrated for a standardized sensitivity of 20µV/mmHg (150 µV/kPa).

Since the transducer electrical calibration may be altered by the effects of variations in monitors, calibration should be confirmed with a pressure manometer to help guarantee the most accurate results.

To properly calibrate and balance the Millar Mikro-Tip P-V catheter pressure transducer, follow the instructions for the control unit being used (For more details please see the “Operating Instructions” section of this manual). To confirm calibration accuracy, compare the pressure output produced using the pressure manometer with the electrical output signal produced by the control unit for the Millar Mikro-Tip P-V catheter pressure transducer (see Schematics section for more detail).

Operating Instructions

1. Unpack the Millar Mikro-Tip P-V catheter, being careful to handle it with a high degree of care.

2. Connect the catheter to the Pressure-Volume control unit.

3. Using a shallow dish, beaker, or syringe, soak the catheter tip in body temperature distilled water or saline for at least 30 minutes prior to insertion into the biological environment.

4. Open the data acquisition software on the computer.

5. Configure the data acquisition software according to user preferences so that it can effectively acquire, display, and record the Pressure-volume data produced by the control unit.

6. *Calibration Setup*: Follow the on-screen instructions displayed from the pressure-volume control unit.

   CAUTION: The "zero" output produced by selecting 0 mmHg in the display software is an electrical zero, not an atmospheric zero.

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7. *Pressure Transducer Balancing:* Follow the on-screen instructions displayed from the pressure-volume control unit.

   CAUTION: Do not submerge the electrical connectors on the catheter.

   For best stability and zero adjustment, shield the sensor from bright ambient light during the balancing procedure and allow the catheter-tip to soak in body temperature sterile water or saline for 30 minutes prior to insertion into the biological environment. Zero balancing of the pressure transducer should be done prior to each catheterization procedure.

NOTE

A pressure manometer may also be used to check the zero balance of the transducer and calibrate the pressure output at two points. To pressurize the transducer, a manometer can be connected to one end of a hemostasis valve or Toughy-Borst/Luer adapter with flexible tubing. Carefully slip the catheter through the other end of the valve/adapter and seal the valve/adapter around the catheter shaft proximal to the sensor/electrode area. See Schematics section for more detail.

8. The system is now ready to begin conducting Pressure-Volume experiments. Prepare the experimental subject for catheter insertion according to the lab's established experimental protocols. When the experimental subject is ready, insert the Millar Mikro-Tip P-V catheter into the ventricle and begin recording Pressure-Volume data. **[Please Note: Millar Instruments recommends a data acquisition sampling rate of at least 1 kHz (1000 samples/second) in order to accurately capture all of the features of the P-V waveforms produced by the fast-beating hearts of mice and rats]**.

Operational Notes

Use appropriate size introducer and/or guide catheter for catheter being used.

Consider use of systemic heparinization.

Cleaning

Approved Cleaners and Disinfectants

Type	Trade Name	Manufacturer	Active Ingredient.	Soak Time/Temperature
Enzymatic Detergent	Enzol® (in UK: Cidezyme®)	Advanced Sterilization Products (J&J)	Propylene Glycol	15 minutes / room temperature
	Endozime®	Ruhoff Corporation	Propylene Glycol	15 minutes / room temperature
	Terg-A-Zyme®	Alconox	Sodium Dodecylbenzene	15 minutes / room temperature
High-Level Disinfectant	Cidex Activated Dialdehyde Solution	Advanced Sterilization Products (J&J)	Glutaraldehyde	1-2 hours / 25 °C (77°F)
	Cidex® OPA	Advanced Sterilization Products (J&J)	Ortho-phthalaldehyde	16-30 minutes / 20 °C (68°F)
	MetriCide®	Metrex	Glutaraldehyde	1-2 hours / 25 °C (77°F)

DO NOT USE:

- Glutaraldehyde solutions containing surfactants (e.g., Cidex 7 or Cidex Plus 28 Day)
- Solutions containing hydrogen peroxide (e.g. Sporox)
- Cidex PA solution

Cleaning Procedure

CAUTION: DO NOT submerge the wye junction or connectors. This will damage the catheter and void its warranty! Wipe with cleaner and gauze.

CAUTION: Use only the listed cleaners and disinfectants for the times/temperatures indicated.

CAUTION: Delays in rinsing greatly reduce cleaning effectiveness!

1. After the Pressure-Volume loop data acquisition is complete, immediately remove the Millar Mikro-Tip P-V catheter from the biological environment. When using the carotid artery approach in small animal (mouse and rat) applications, loosen the proximal suture before pulling the catheter back through the blood vessel. Loosening the proximal suture will help prevent the electrodes and pressure sensor from catching on the suture and breaking.
2. Upon removing the Millar Mikro-Tip P-V catheter from the biological environment, immediately soak the catheter tip in a beaker, syringe, or dish filled with fresh saline or distilled water (DO NOT use hot water). Keep the tip soaking until you are ready to continue cleaning it or you are ready to catheterize another research subject. This step will help lyse any cells that adhere to the catheter and help loosen and prevent clot formations and protein build-up on the catheter tip.
3. If large amounts of contaminants can be seen on the catheter, remove with wetted gauze by wiping carefully.

NOTE

Never let blood dry on the catheter tip! Always keep the tip soaking in saline or distilled water between experiments or until you are ready to proceed with the next cleaning step.

Do not submerge the catheter connectors, as moisture will damage the sensitive electronics that are housed inside!

4. The Millar Mikro-Tip P-V catheter should be thoroughly inspected under magnification after each use to determine its condition. Carefully examine the catheter for cuts, kinks, or creases. The active surface of the sensor and electrodes should be examined for any film or biological debris. Any film may cause short-term baseline drift and should be removed. Such removal should consist of a thorough soaking in Terg-A-Zyme (see below) followed by a persistent and gentle wiping action along the sensor or electrodes with a moist tissue, gauze or cotton tipped swab. The connectors should undergo visual inspection for corrosion or bad contacts.
5. Using an enzymatic cleaner on the distal portion of the Millar Mikro-Tip P-V catheter is essential to preventing protein buildup on the pressure sensor and electrodes. Without the use of an enzymatic cleaner, a protein film will form on the pressure sensor that ultimately results in pressure signal drift. Millar provides the following guidelines for using enzymatic cleaners with the Pressure-Volume catheters:
    - Use a Millar approved enzymatic cleaning agent such as Terg-A-Zyme by Alconox. www.alconox.com.
    - Follow the manufacturer's instructions for mixing the Terg-A-Zyme solution.
    - Soak the catheter tip in a beaker or syringe for 15-30 minutes in the Terg-A-Zyme solution.
    - After the Millar Mikro-Tip P-V catheter is done soaking in the enzymatic cleaning solution, thoroughly rinse the tip with fresh distilled water.
6. After the rinsing is complete, gently dry the Millar Mikro-Tip P-V catheter according to the following steps:
    - Fold a Kim-wipe or similar soft tissue.
    - Use gentle stroking to brush dry the catheter tip.
    - Do not pull the catheter tip through a folded Kim-wipe.
    - Do not allow the catheter to air dry on the tray, table, or countertop.

7. After the cleaning procedure is complete, return the Millar Mikro-Tip P-V catheter to its original packaging for storage:
    - Return the catheter to the tray.
    - Protect the sensor/electrode area on the catheter tip by carefully placing it within the foam dome or plastic tubing that came with the packaging.
    - Slide the tray inside the box.
    - Store the catheter in a cool, dry place until the next use.

General Instructions for Catheter Disinfection

1. The catheter must be cleaned, rinsed, and dried prior to disinfection. Soil, debris, proteins, and water can interfere with the effectiveness of the following procedure, posing a risk to the patient and the user. Note that some disinfectants have a limited usable life after activation or opening the container. Failure to heed such warnings can inhibit the effectiveness of the disinfection process.
2. Prepare the disinfectant according to the manufacturer's instructions.
3. Submerge the catheter into the disinfectant up to the strain relief. Do not submerge the strain relief or the connector as it will damage the transducer and void the warranty.
4. Soak the transducer in the disinfectant at the temperature and time intervals listed.

Rinsing after Disinfection

1. Rinse the device by submerging all exterior disinfected surfaces in sterile pyrogen-free water. The volume of the water should be at least two gallons (7.6 liters) and the soak time should be at least one minute.
2. At least three separate rinses are required. Do not reuse any of the water used for rinsing since it will be contaminated with the disinfectant.

CAUTION: DO NOT sterilize by EtO, autoclaving, radiation (gamma or e-beam), plasma, peroxide or formaldehyde vapor solutions.

Sensor Specifications

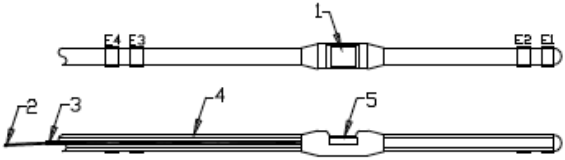
	1.1F – 5F Catheter
Type of Sensor	Diffused Semiconductor, piezoresistive
Pressure Range	-50 to +300 mmHg (-6.7 to 40 kPa)
Overpressure	+4000 mmHg (+530 kPa), -760 mmHg (-100 kPa)
Rated Voltage*	4.0 to 5.5 V_{DC}
Fixed Bridge Excitation Voltage	3.8 V_{DC}
Sensitivity	20 µV/mmHg, nominal (150 µV/kPa)
Temperature Error Band at Zero Pressure	± 3 mmHg (± 0.4 kPa) BSL, 23 - 38 ºC
Linearity and Hysteresis (Combined)	± 2%, BSL of full scale
Accuracy (nonlinearity, hysteresis, sensitivity, and repeatability combined)	± 1 mmHg (0.13 kPa) ±1% of reading from -50 to 50 mmHg (-6.7 to 6.7 kPa) ±3% of reading from 50 to 300 mmHg (6.7 to 40 kPa)
Drift**	≤ 2.5 mmHg (0.33 kPa) in 4 hours
Natural Frequency	Flat to ≥10 kHz
Bridge Resistance	1000 ohms, nominal
Reference Pressure	Atmospheric
Zero Offset	< ± 50 mmHg (± 6.7 kPa)

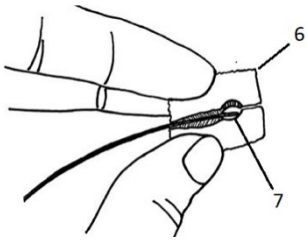
* Performance specifications are for 5.0 V_{DC} input voltage and 3.8 V_{DC} fixed bridge voltage. Transient voltages up to 20 volts will not damage the transducer.

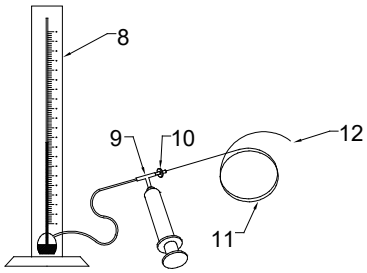
** Based on 30-minute presoak.

NOTE: Specifications subject to change without notice.

Schematics







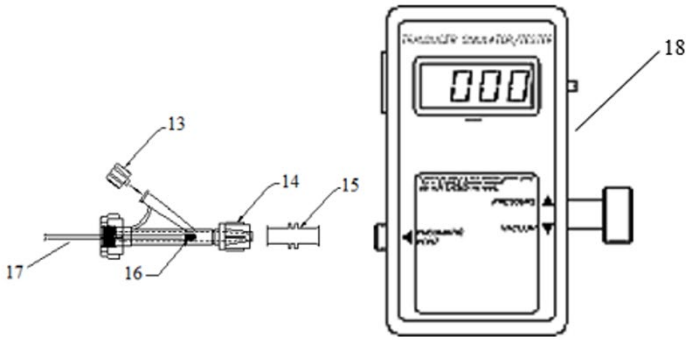


Figure Legend

1.	Pressure Sensing Area	10.	Hemostasis Valve
2.	Wires to Connector	11.	Pressure Transducer Catheter
3.	Vent to Connector	12.	Catheter Tip
4.	Catheter	13.	Cap, Low profile connector
5.	Silicone Rubber Diaphragm	14.	Valve, Passage Hemostasis
6.	Foam Dome supplied with ≤2F catheters.	15.	Fitting, coupler female
7.	Catheter Tip	16.	Catheter Tip
8.	Mercury Manometer	17.	Catheter
9.	Tee Fitting	18.	Pressure Transducer Calibration Device/Simulator

Service Provision

Consult web site below for service information:

www.millar.com

Millar Limited Warranty

Millar warrants that at the time of sale to the original purchaser, the device shall be free from defects in materials and workmanship for a period of six (6) months from its date of shipment to the original purchaser. If there is such a defect, Millar will, at no charge and at its option, either repair or replace any Millar Mikro-Tip P-V catheter as appropriate. Millar's limited warranty does not cover damage to the product from alterations, misuse, abuse, negligence, or accident.

The user shall determine the suitability for use of these devices for research purposes only. Therefore, the user accepts these devices subject to all the terms hereof. Furthermore, Millar does not warrant that the equipment is suitable for any specific purpose, other than that explicitly stated by Millar.

In addition, Millar makes no warranty regarding device efficacy after three (3) years from the date of manufacture. Catheters beyond the age of three (3) years will not be considered for evaluation or repair**.**

This warranty is in lieu of and excludes all other warranties not expressly set forth herein, whether expressed or implied warranties of merchantability or fitness of purpose. Since handling, storage, cleaning, and sterilization of the product, as well as factors relating to catheterization procedures, and other matters beyond Millar's control directly affect the product and the results obtained from its use, Millar shall not be liable for incidental or consequential loss, damage, or expense directly or indirectly arising from the use of this product.

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Millar Worldwide Distribution
Millar, LLC has a worldwide exclusive distribution agreement in place with ADInstruments for the sale and support of its research-based Mikro-Tip P-V catheter technology. For information on the Millar distributor in your country, please contact ADInstruments.

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