

ORGAN BATH SYSTEM - 820MO

USER GUIDE VOL. 3.5



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CHAPTER 1 - ORGAN BATH OVERVIEW

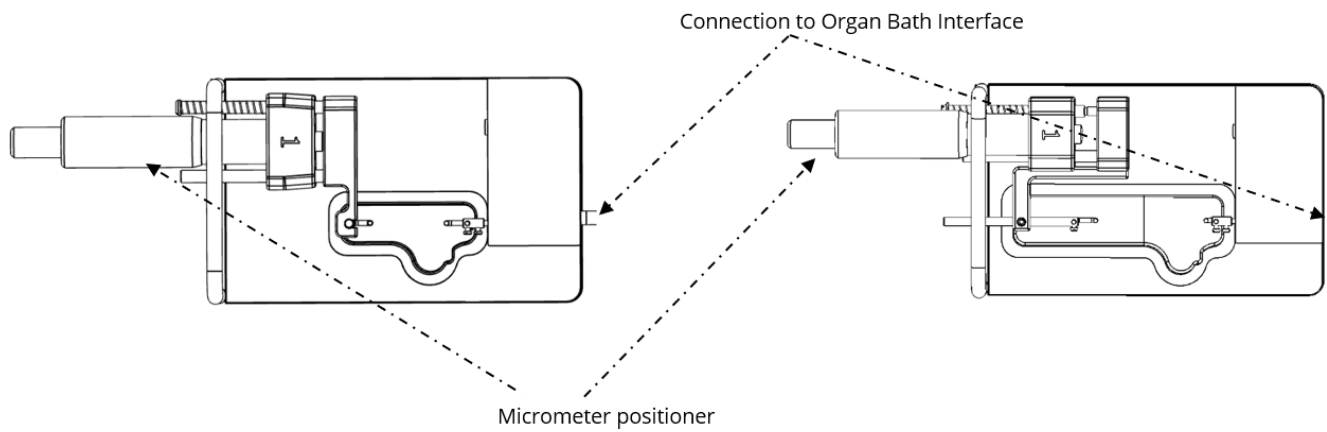


Figure 1.3 820MO Organ bath chamber unit and 820MO-XL Chamber Unit with mounting.

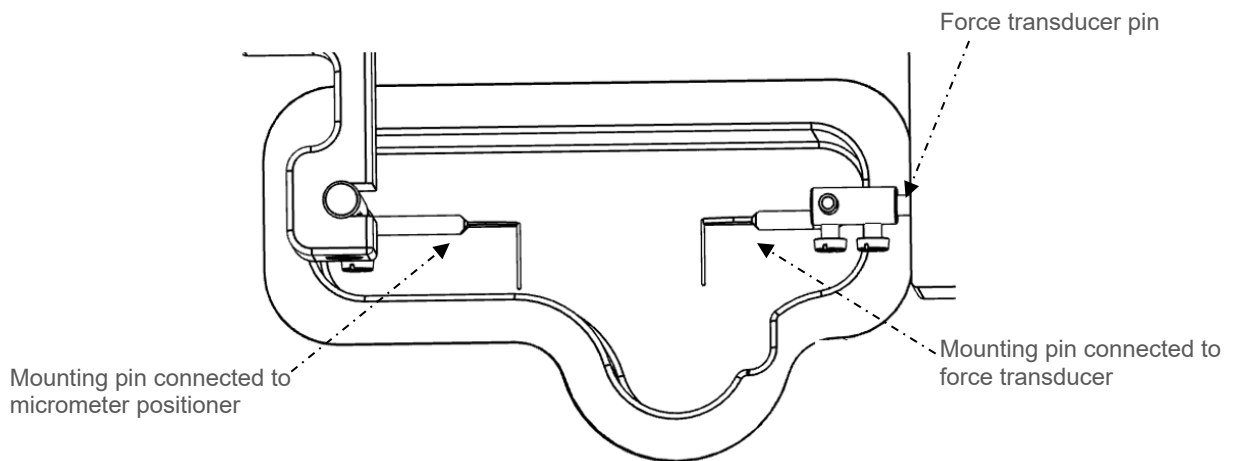


Figure 1.4 Close-up of the 820MOmyograph chamber unit with mounting pins.

CHAPTER 2 - SETTING UP THE ORGAN BATH

2.1 CHANGING AND ADJUSTING THE MOUNTING SUPPORTS

Each chamber can accommodate mounting supports for larger segments (>500 μ m). The mounting supports can easily be changed, and the experiments can be performed with different tissue sizes. Tissue segments with length/diameter up to 19mm are mounted in the 820MO chamber. Tissue segments with lengths/diameters up to 45mm are mounted in the 820MO-XL chamber. Continuous use and repeated greasing of the transducer arm holes will cause misalignment of the mounting supports. The mounting supports will need occasional adjustments. The mounting supports are changed and adjusted using the following step-by-step procedure.

OBS:

THE TRANSDUCERS ARE FRAGILE AND SENSITIVE TO MECHANICAL STRAIN. BE VERY CAREFUL WHEN CHANGING OR ADJUSTING THE MOUNTING SUPPORTS

2.1.1 CHANGING THE MOUNTING SUPPORTS

1. Use the micrometer to separate the supports as far apart as possible.
2. Use the small screwdriver provided to loosen screw "C" gently" (figure 2.1A and 1.2B) on the support attached to the force transducer side. Screw "C" is the screw on the support closest to the transducer.
3. Gently pull the support away from the Force transducer pin.
4. Loosen screw "A" on the micrometer side with the appropriate Allen key.
5. Pull the pin support away.

NOTE:

NUMBER THE MOUNTING SUPPORTS WITH THE NUMBER OF THE CHAMBER THEY WERE REMOVED FROM WITH A PERMANENT MARKER. STORE THE MOUNTING SUPPORTS IN THE PROVIDED PLASTIC CASE. NUMBERING THE MOUNTING SUPPORTS WILL SAVE TIME WHEN THE MOUNTING SUPPORTS ARE CHANGED AGAIN, MINIMIZING THE NUMBER OF ADJUSTMENTS NEEDED AFTER EACH CHANGE.

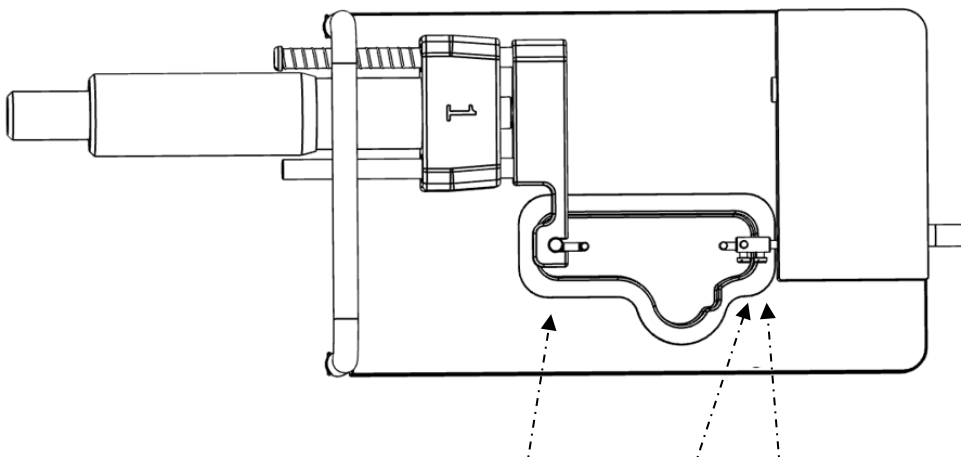


Figure 2.1A Illustration of the screws for changing and adjustments of the mounting supports.

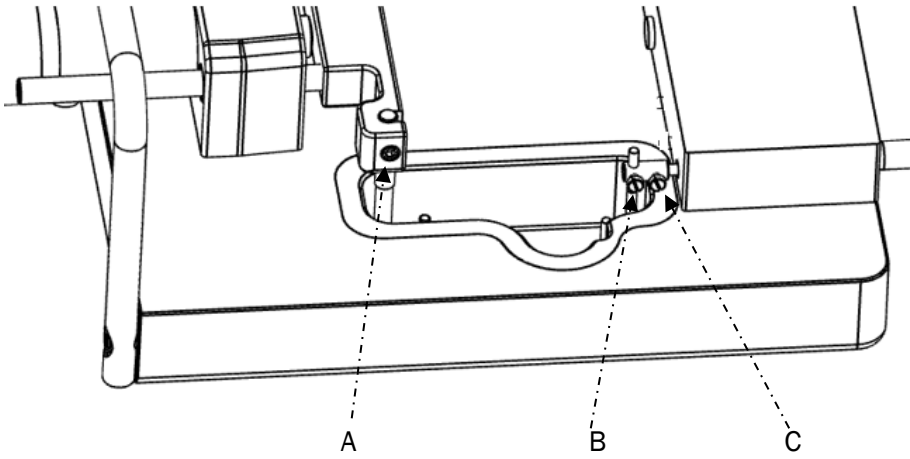


Figure 2.1B Illustration of the screws for changing and adjustments of the mounting supports.

2.1.2 FINE ADJUSTING OF THE MOUNTING SUPPORTS

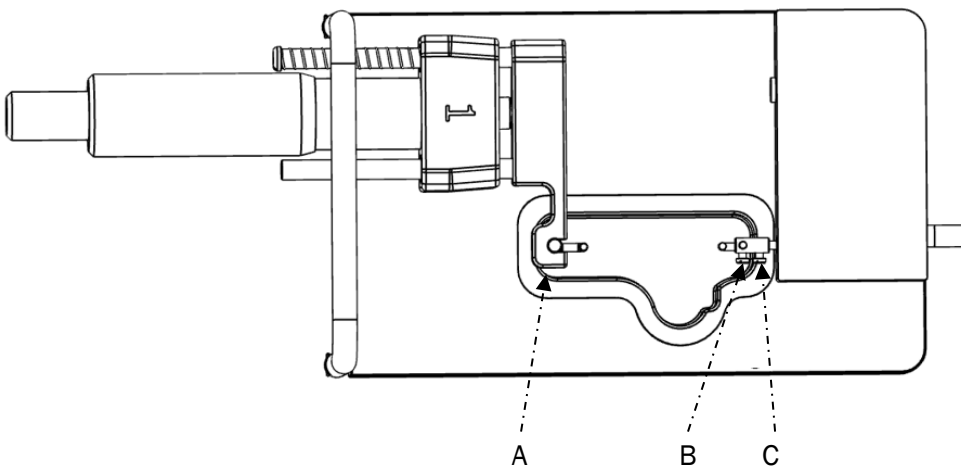


Figure 2.2A Illustration of the screws for changing and adjustments of the mounting supports.

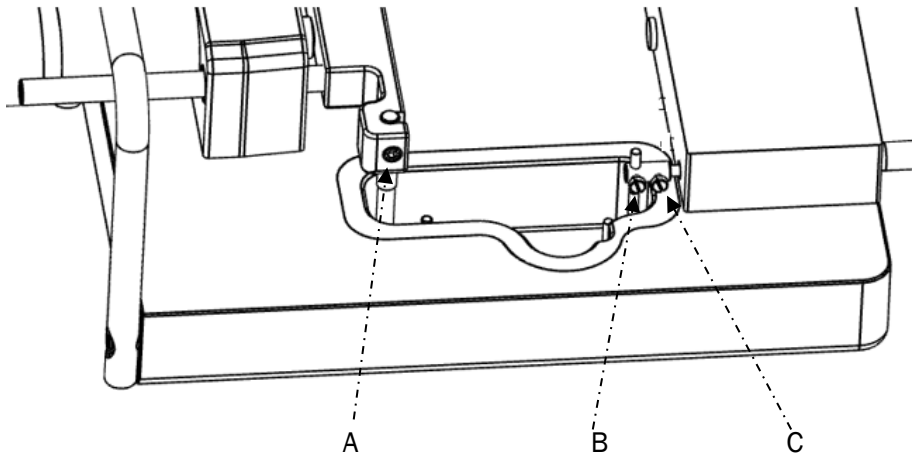


Figure 2.2B Illustration of the screws for changing and adjustments of the mounting supports.

1. Loosen screw "A" to move the micrometer-side arm holder sideways and up and down (figure 2.2A and 2.2B).
2. Loosen screw "B" to move the mounting supports on the force transducer side sideways, rotate, and up and down (figure 2.2A and 2.2B).

Alignment of mounting pins for larger ring preparations (mounting pins – optional)

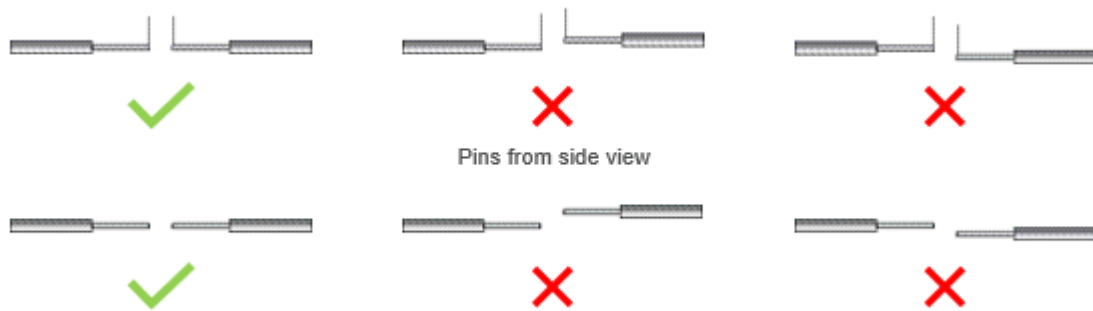


Figure 2.3 Illustrations of properly aligned Mounting pins and incorrectly aligned Mounting pins.

2.2 CALIBRATION OF THE FORCE TRANSDUCER

As a part of the general maintenance of the Tissue Bath, DMT recommends that the Tissue Bath is force calibrated at least once a month. The Tissue Bath should also be force calibrated every time the Multi Interface has been moved. Although lab benches are all supposedly perfectly horizontal, small differences in lab bench pitch can affect the system's calibration. The Tissue Bath should also be calibrated if the system has been idle for over a month. A step-by-step procedure is explained in Chapter 3.2 in the Organ Bath System - User Manual.

CHAPTER 3 - EXPERIMENTAL SET-UP

Each chamber contains supports with mounting hooks, pins, or clamps (Optional) to facilitate tissue mounting in the organ bath chambers.

3.1 How to mount tissue ring preparations on Mounting pins (Optional).

Below is a short description of how to mount a tissue ring preparation on the Mounting Pins of the 820MO system. DMT delivers the 820MO system with 200 μ m pins, allowing the user to mount ring preparation with an internal diameter of 450 μ m and up. For large tissue ring preparation with the ability to make high force contractions, the 200 μ m pins may be too thin. DMT can deliver mounting pins with the following thicknesses:

L-shaped mounting pins (Diameter): 100 μ m, 200 μ m, 250 μ m, 300 μ m and 400 μ m.

The 820MO Chambers can accommodate ring preparations with internal diameters up to 9mm, and the 820MO-XL chambers can accommodate ring preparations with an internal diameter up to 27mm.

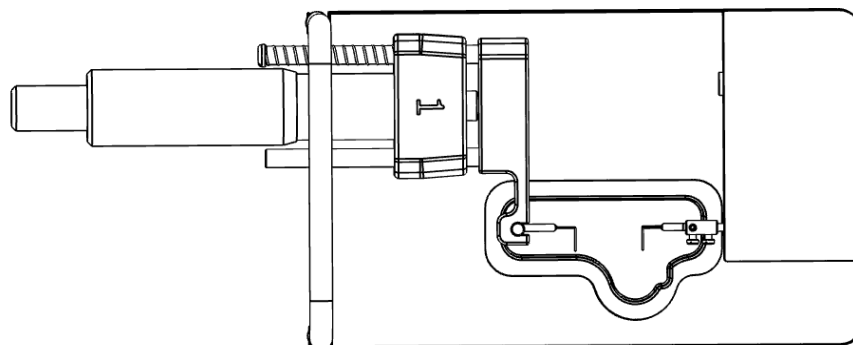
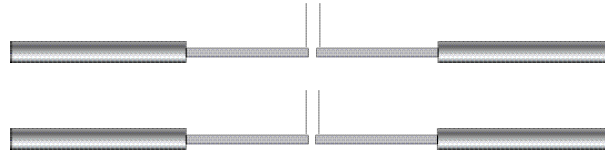


Figure 5.1. 820MO Chamber unit with Mounting Pins.

1. Fill the chamber with a given buffer (5-7ml) (see Appendix 1 for Buffer recipes).

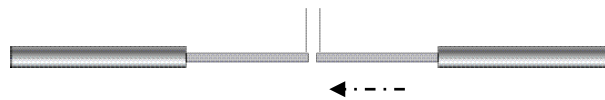
DO NOT FILL THE CHAMBER TO THE EDGE.

2. Make sure that the tissue Mounting pins are correctly aligned.

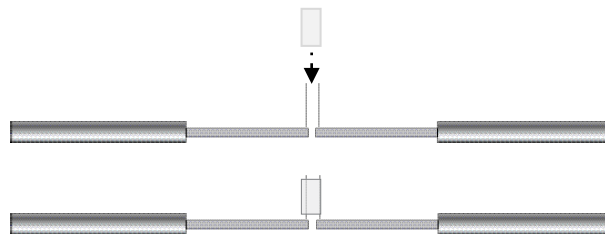


Properly aligned pins, seen from the side and above.

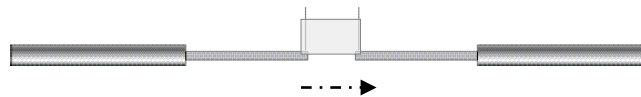
3. Use the micrometer to get the pins as close together as possible without touching each other.



4. Slide your tissue ring preparation onto the two mounting pins.



5. Slowly move the pins apart using the micrometer until the force reading increases.



6. The tissue is now mounted and ready for a normalization protocol (see Chapter 3.2), finding the optimal pre-load tension for the mounted tissue.
7. Place the micrometer at the position giving the optimal pre-load tension on the mounted tissue.
8. Continue with a standard start (see chapter 3.3).
9. The mounted tissue is now ready for experiments.

3.2 How to mount a tissue preparation on the Mounting hooks using suture.

The 820MO and 820MO-XL are delivered with suture, allowing the user to mount tissue/muscle preparation with lengths up to 14mm and in the 820MO-XL chambers up to 44mm.

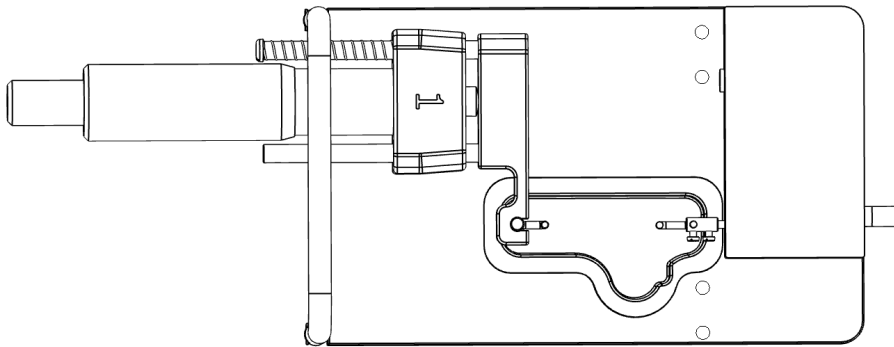
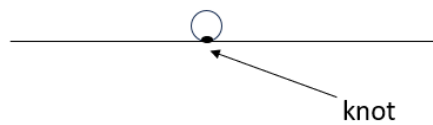


Figure 5.2. 820MO Chamber unit with Mounting Hooks.

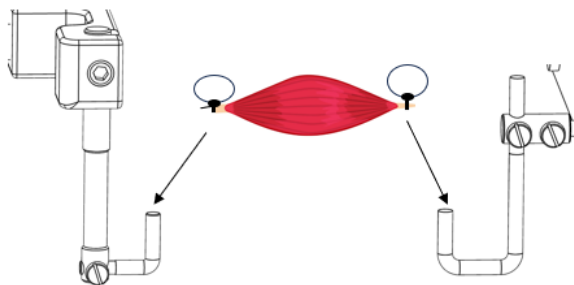
The hooks are for mounting tissue with the suture delivered with the system. Below is an example of how to mount a muscle to the hooks with suture.

_____ 8cm suture

1. Tie a knot that generates a fixed loop fitting on the hooks. You can make a lot of these and save them until use.

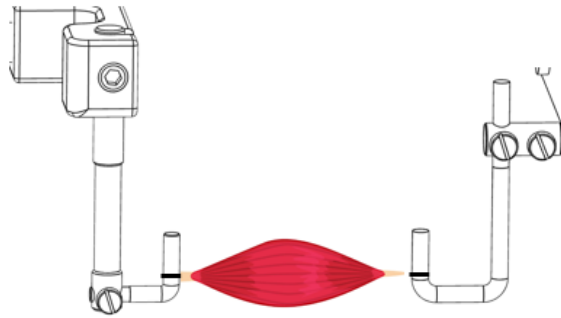


2. Tie one suture with the fixed loop to each end of the muscle.

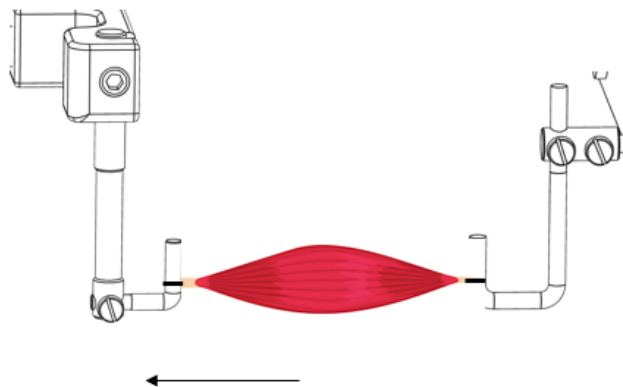


3. Lower the loops onto the hooks.

4. Stretch the mounted tissue to apply the optimal pre-load tension.



5. The mounted tissue is now ready for experiments.



3.3 How to mount tissue strips on Mounting clamps (Optional).

Below is a short description of how to mount tissue strips on clamps. These clamps have been designed to optimally "clamp" the tissue without slipping during a contraction. They are also designed to effectively "grab" tendons on whole striated muscle preparations without experiencing "slippage" during an entire striated muscle contraction.

1. Starting position.



2. Loosen the screws on the mounting clamps.



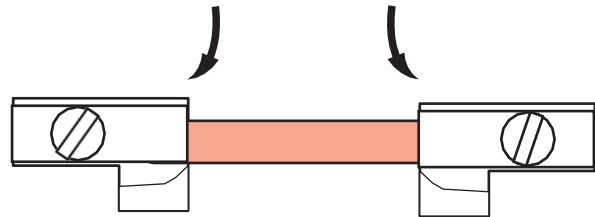
3. Turn the upper wings of the mounting clamps to expose the base of the support.



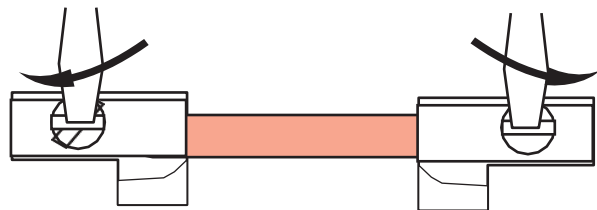
4. Place the muscle strip onto the base of the mounting clamp.



5. Turn the upper wings back into position so that the muscle strip is clamped between the wings and base of the mounting clamp.



6. Secure the screws.



IMPORTANT:

BE VERY CAREFUL WHEN TIGHTENING THE SCREW ON THE TRANSDUCER SIDE. EXCESSIVE PRESSING DOWN ON THE SCREW OR EXCESSIVE TORQUE FORCE WILL DAMAGE THE FORCE TRANSDUCER.

2.3 NORMALIZATION - OPTIMAL PRE-LOAD TENSION

The normalization procedure aims to stretch the mounted muscle/tissue segment to an optimal pre-load tension, giving maximum response by muscle contraction. The contraction can be induced chemically, e.g., by adding high potassium or, e.g., electric field stimulation.

GENERAL

In principle, the normalization is steps of stretching the mounted tissue and a contraction stimulus. Here below is an example:

- 1) Start: Make sure there is no tension applied to the mounted tissue. Zero the force.
- 2) Stretch the tissue to a tension of, e.g., 1mN (dependent on the type of tissue and can be from 0.5mN to 10mN)
- 3) Stimulate the tissue to contract, e.g., by high potassium or, e.g., electric field stimulation. Record the force.
- 4) Stop the stimulus, ensuring the tissue relaxes to baseline.

- 5) Stretch the tissue again to a higher tension, e.g., 2mN (dependent on the type of tissue and can be from 1mN to 20mN)
- 6) Stimulate the tissue to contract, e.g., by high potassium or, e.g., electric field stimulation. Record the force.
- 7) Stop the stimulus, ensuring the tissue relaxes to the baseline.
- 8) Repeat steps 5-7 until the difference between the baselines and the maximal contraction force no longer increases.

The pre-load tension (force) resulting in the maximal force contraction during a contraction stimulus is the optimal pre-load for an experiment.

STRIATED MUSCLE

Please see the Striated Muscle Guide on the DMT homepage for striated muscle.

VESSEL TISSUE

DMT highly recommends the user read the DMT Normalization Guide before performing any experiments on arteries. The Normalization guide can be downloaded on www.dmt.dk.

The importance of normalizing the preparation is three-fold:

1. Experiments with elastic preparations like vessels can only have meaning if performed under conditions where the size is clearly defined.
2. Clearly defined conditions are required in pharmacological experiments, as the sensitivity of preparations to agonists and antagonists depends on the amount of stretch.
3. The active response of a preparation depends on the extent of stretch, which makes it essential to set the preparation to an internal circumference or pre-load tension, giving a maximal response of a given tissue mounted in the 820MO chambers.

The normalization procedure aims to stretch the mounted muscle segment to an optimal pre-load tension, giving maximum response by muscle contraction for arteries. The so-called normalized internal circumference (IC1) is a set fraction of the internal circumference (IC100) that a fully relaxed segment would have at a specified transmural pressure. For small rat arteries, the target transmural pressure is typically 100mmHg = 13.3 kPa.

3.2.1 PRINCIPLES OF THE NORMALIZATION PROCEDURE

In practice, the normalization is performed by distending the segment stepwise and recording the passive and the active force (stimulation of the muscle to contract) after each stretch. The optimal pre-load tension is at the passive force, where the active force minus the passive force reaches a maximum.

VESSEL/ARTERIES

For arteries, the force sets of micrometer and force readings (figure 3.8) data are converted into values of the internal circumference (μm) and wall tension T (mN/mm), respectively.

Plotting wall tension against internal circumference reveals an exponential curve, and by applying the isobar curve corresponding to 100mmHg, IC100 is calculated from the point of intersection using the Laplace relation (figure 3.9). IC1 is calculated from IC100 by multiplying a factor giving an internal circumference at which the active force production, as well as the sensitivity to agonists of the segment, is maximal. The factor for rat mesenteric arteries is 0.9 but both this factor and the transmural pressure must be optimized for each segment. The normalized internal diameter is calculated by dividing IC1 with IC100

The DMT Normalization Guide contains a complete description of the mathematical rationale and calculations of the normalization procedure.

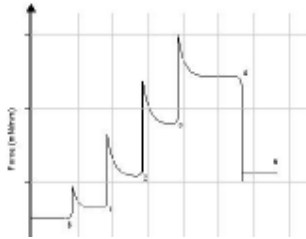


Figure 3.8 Illustration of the stepwise normalization procedure for arteries

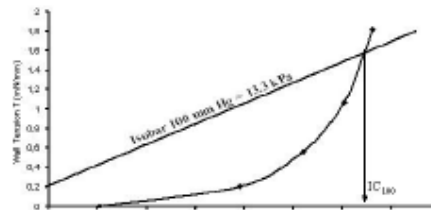


Figure 3.9 Illustration of the exponential curve fitting and determination of IC₁₀₀

3.3 STANDARD START

The purpose of performing a standard start is to:

1. Re-activate the mechanical and functional properties of the mounted segment.
2. Check that responses to different stimuli are normal in appearance, ensuring that the tissue segment's functionality has not been damaged during the dissection or mounting procedures.
3. Ensure that the tension development gives an effective active contraction force.

The standard start is performed after the mounted segment has been heated, equilibrated, and normalized.

3.3.1 PRINCIPLES OF THE STANDARD START PROCEDURE FOR VESSEL TISSUE

The standard start procedure consists of a series of five stimuli and washout periods. The first two stimuli are performed using a mixture of KPSS and 10 μ M noradrenaline to give a maximum contractile response. The third stimulus is performed using a mixture of PSS and 10 μ M noradrenaline to provide a maximum pure agonist-mediated (α -adrenoceptor) contraction. The fourth stimulus is performed using KPSS to give a depolarizing contractile response (this stimulus also includes a component from neurally released noradrenaline). The final stimulus is performed using a mixture of PSS and 10 μ M noradrenaline. All solutions are preheated to 37°C and aerated with a mixture of 95% O₂ and 5% CO₂ before use. Instructions for making the necessary solutions are described in Appendix 1.

Repeat 1 x



3.4 ENDOTHELIUM FUNCTION FOR VESSEL TISSUE

The reasons for checking endothelium function may include:

1. To check whether the relaxing function of the endothelium is intact. The procedure ensures the endothelium is not damaged during the dissection or mounting procedure.
2. If an experiment requires removal of the endothelium, this procedure is useful to check whether the endothelial cells were successfully removed.

The procedure can be performed after the vessel segment has been heated, equilibrated, and normalized. Preferably, the procedure should be done after completing a standard start to make sure that the vessel segment is viable.

The present procedure is for use with rat mesenteric arteries. Another procedure may be needed for other animal species, tissue, or vessel types.

3.4.1 PRINCIPLES OF CHECKING ENDOTHELIUM FUNCTION

Stimulating a vessel segment with acetylcholine causes a release of nitric oxide (NO, also known as EDRF) from the endothelium cells and subsequent relaxation of the vascular smooth muscle cells. If the endothelium is undamaged by the dissection and mounting procedures, then a substantial relaxation will occur. With complete removal or damaged endothelium, a partial relaxation or no relaxation to acetylcholine is observed.

It is important to note that the amount of NO or EDRF in a vessel often depends upon its size. In certain vessels, endothelium-derived hyperpolarizing factor (EDHF) can contribute more or less than EDRF. In other vessels, the same stimulation with ACh can promote the release of endothelium-derived contracting factor (EDCF). Therefore, it is essential to check the existing literature to determine the expected response in your particular vessel with the given agonist concentration.

3.5 IN VITRO EXPERIMENT 1: NORADRENALINE CONTRACTILE RESPONSE FOR VESSELS

The purpose of the present protocol is to determine the sensitivity of rat mesenteric small arteries to the vasoconstrictor noradrenaline/norepinephrine with a cumulative concentration-response curve.

3.5.1 BACKGROUND

Noradrenaline (norepinephrine) causes contraction of mesenteric small arteries by activating α -adrenoceptors, whereas noradrenaline activation of β -adrenoceptors causes vasodilatation. As the purpose is to determine the contraction sensitivity to noradrenaline, the vasodilatory effect of noradrenaline is eliminated throughout the experiment by the constant presence of the β -adrenoceptor antagonist, propranolol.

Rat mesenteric arteries are densely innervated by sympathetic nerves, which have a highly efficient reuptake mechanism that removes noradrenaline from the neuromuscular junction. The reuptake mechanism will create a concentration gradient between the solution around the vessel segment and the receptors on the smooth muscle. To correctly determine the sensitivity to noradrenaline, it is necessary to eliminate this concentration gradient by performing the experiment in the presence of cocaine to block the noradrenaline reuptake.

The vessel segment is exposed to increasing noradrenaline concentrations to determine the sensitivity to noradrenaline. Each concentration is applied until a steady response is reached, and the next concentration is applied. When the vessel segment is fully contracted or does not respond more upon increasing the noradrenaline concentration, the experiment is ended.

3.5.2 PROTOCOL

Prepare the following stock solutions:

Prepare the following stock solutions:
Acetylcholine: 10^{-4} M, 10^{-3} M, 10^{-2} M
Noradrenaline: 10^{-2} M

1. Mount and normalize the vessels as described in chapters 3.1 and 3.2.
2. Perform a standard start as described in Chapter 3.3.
3. Incubate the vessel segment in $1\mu\text{M}$ propranolol (add $5\mu\text{L}$ of 10^{-3}M to 5mL PSS in the chamber) and $3\mu\text{M}$ cocaine (add $15\mu\text{L}$ of 10^{-3}M to 5mL PSS in the chamber) for at least 10 minutes.
4. Add increasing noradrenaline concentrations into the bath (use the table below as a guideline). Wait for a stable contractile response or a standard time, such as 2 minutes between each application.

[NA] in chamber (μM)*	Volume of stock solution to add to chamber
0.1	$5\mu\text{L}$ of 10^{-4} M
0.3	$1\mu\text{L}$ of 10^{-3} M
0.5	$1\mu\text{L}$ of 10^{-3} M
1	$2.5\mu\text{L}$ of 10^{-3} M
1.3	$1.5\mu\text{L}$ of 10^{-3} M
1.5	$1\mu\text{L}$ of 10^{-3} M
3	$7.5\mu\text{L}$ of 10^{-3} M
5	$1\mu\text{L}$ of 10^{-2} M
10	$2.5\mu\text{L}$ of 10^{-2} M

**In calculating the [N.A.] in the chamber, the applied volume of noradrenaline is ignored.*

3.6 IN VITRO EXPERIMENT 2: ACETYLCHOLINE RELAXATION CURVE FOR VESSELS

The protocol aims to determine the sensitivity of the endothelium-dependent vasodilator acetylcholine in noradrenaline pre-contracted rat mesenteric small arteries.

3.6.1 BACKGROUND

Acetylcholine causes relaxation of rat mesenteric small arteries by activating muscarinic M3 receptors at the endothelial cell layer, releasing endothelium-derived relaxing factors.

Rat mesenteric arteries do not show spontaneous tone in the Tissue Bath, so it is necessary first to induce a contraction to observe the relaxation to acetylcholine. In this protocol, the contraction is induced by noradrenaline. The required concentration of noradrenaline needs to be optimized since a too-low concentration makes it impossible to evaluate the relaxation. On the other hand, it may be difficult to relax super maximally contracted arteries, leading to underestimating the sensitivity to acetylcholine. Therefore, it is recommended to apply a concentration of noradrenaline inducing 60-70% of maximal contraction response. In practice, this concentration is found by performing a noradrenaline concentration-response curve, as described in the previous section.

The vessel segment is exposed to the noradrenaline concentration, and when the response has stabilized, increasing concentrations of acetylcholine are added to relax the vessel. Each concentration is applied until a steady response is reached, and the next concentration is applied. When the vessel segment is either fully relaxed or does not relax more upon increasing the acetylcholine concentration, the experiment is ended.

3.6.2 PROTOCOL

Prepare the following stock solutions:

Acetylcholine: 10^{-4} M, 10^{-3} M, 10^{-2} M

Noradrenaline: 10^{-2} M

1. Mount and normalize the vessels as described in chapters 3.1 and 3.2.
2. Perform a standard start and check the vessel segment for endothelium function, as described in chapters 3.3 and 3.4.
3. Add noradrenaline to obtain a response around 60% of maximum (determined from the previous noradrenaline concentration-response curve). When the contractile response is stable, add increasing acetylcholine concentrations to the chamber, using the table below as a guideline. Wait for a stable contractile response or a standard time, such as two minutes between each application.

[ACh] in chamber (μM)*	Volume of stock solution to add to chamber
0.1	5 μL of 10^{-4} M
0.3	1 μL of 10^{-3} M
0.5	1 μL of 10^{-3} M
1	2.5 μL of 10^{-3} M
1.3	1.5 μL of 10^{-3} M
1.5	1 μL of 10^{-3} M
3	7.5 μL of 10^{-3} M
5	1 μL of 10^{-2} M
10	2.5 μL of 10^{-2} M

**In calculating the [ACh] in the chamber, the applied volume of ACh is ignored.*

CHAPTER 4 - CLEANING AND MAINTENANCE

4.1 CLEANING THE ORGAN BATH

DMT STRONGLY RECOMMENDS THAT THE ORGAN BATH AND SURROUNDING AREAS ARE CLEANED AFTER EACH EXPERIMENT.

At the end of each experiment, use the following procedure to clean the Tissue Bath.

1. Fill the chamber to the edge with an 8% acetic acid solution and allow it to work for a few minutes to dissolve calcium deposits and other salt build-up. Use a cotton-tipped applicator to clean all chamber surfaces mechanically.
2. Remove the acetic acid and wash the chamber and supports with double distilled water several times.
3. If any kind of hydrophobic reagent has been used that might be difficult to remove using steps 1) and 2), then try incubating the chamber and supports with 96% ethanol or a weak detergent solution (i.e., 0.1% triton-100).
4. To remove more resistant or toxic chemicals, incubate the chamber and supports with 1M HCl for 1-2 min. In exceptional cases, incubate the chamber and supports with no stronger than a 3M HNO₃ solution for about 1-2 minutes.
5. Wash the chamber and supports several times with double distilled water.
6. If acids such as 1M HCl and 3M HNO₃ are used to clean the chambers, ensure ALL surfaces are thoroughly dried after copious washes with double distilled water. Any residual acid will cause corrosion of the stainless-steel pins.

To prevent the tubing from becoming blocked with buffer salt deposits after an experiment, remove the chamber cover from the Tissue Bath, turn on the vacuum, and press the valve for about 10 seconds by pressing the valve button(s). Turn off the vacuum and gas supply. Remove any water or buffer remaining in the chamber or tubing using absorbent paper.

IMPORTANT NOTES:

BE VERY CAREFUL USING HCL OR HNO₃ BECAUSE THESE ACIDS MAY CAUSE EXTREME DAMAGE TO THE STAINLESS-STEEL CHAMBERS AND SUPPORTS. DO NOT USE BLEACH TO CLEAN THE CHAMBERS. REPEATED USE OF CHLORINATED SOLUTIONS SUCH AS BLEACH AND HCL WILL CAUSE DAMAGE TO THE STAINLESS-STEEL PARTS OF YOUR TISSUE BATH. AVOID USING THEM IF AT ALL POSSIBLE.

AFTER CLEANING, ALWAYS CHECK THAT THE GREASE AROUND THE TRANSDUCER PIN IS SUFFICIENT TO KEEP THE BUFFER AND WATER FROM ENTERING THE TRANSDUCER HOUSING (SEE FIGURE 4.1).

If red or brown discolorations appear on the chamber sides or the supports, the following cleaning procedure will work in most cases:

7. Incubate the chamber and supports for 30 minutes with 2mM T-1210 Tetrakis- (2-pyridyl methyl)-ethylenediamine solution dissolved in double distilled water.
8. Use a cotton-tip applicator to mechanically clean all the affected surfaces during the last 15 minutes of the incubation period.
9. Wash the chamber and supports several times with double distilled water.
10. Incubate the chamber with 96% ethanol for 10 minutes while continuing the mechanical cleaning with a cotton-tip applicator.
11. Remove the ethanol solution and wash it twice with double distilled water. Incubate the chamber and supports with an 8% acetic acid solution for 10 minutes and continue the mechanical cleaning with a swab stick.
12. Wash the chamber and supports several times with double distilled water.
13. Dry the surfaces using absorbent paper or cotton-tip applicators.

IMPORTANT NOTES: IN EXCEPTIONAL CASES, THE SUPPORTS MAY BE REMOVED FROM THE CHAMBER AND CLEANED INDIVIDUALLY TO ENSURE PROPER CLEANING OF ALL SURFACES. NEVER SOAK THE SUPPORTS IN ANYTHING STRONGER THAN 8% ACETIC ACID FOR EXTENDED PERIODS (I.E. SEVERAL HOURS OR OVERNIGHT).

4.2 MAINTENANCE OF THE FORCE TRANSDUCER

The force transducer is the most delicate and fragile component of the Tissue Bath. Extreme care should be used when handling or touching the force transducers. As a part of daily maintenance, inspect the grease around the transducer pin extending from the transducer housing pinhole before starting any experiment; see figure 4.1 below. Insufficient grease in this area will allow buffer and water to enter the transducer housing and cause damage to the force transducer.

IMPORTANT NOTES

DMT RECOMMENDS THAT THE HIGH VACUUM GREASE SEALING THE TRANSDUCER PINHOLE IS CHECKED AND SEALED AT LEAST ONCE A WEEK, ESPECIALLY IF THE TISSUE BATH IS USED FREQUENTLY.

DMT TAKES NO RESPONSIBILITY FOR THE USE OF ANY OTHER KIND OF HIGH VACUUM GREASE OTHER THAN THE ONE AVAILABLE FROM DMT.

DMT TAKES NO RESPONSIBILITY FOR ANY DAMAGE TO THE FORCE TRANSDUCERS.

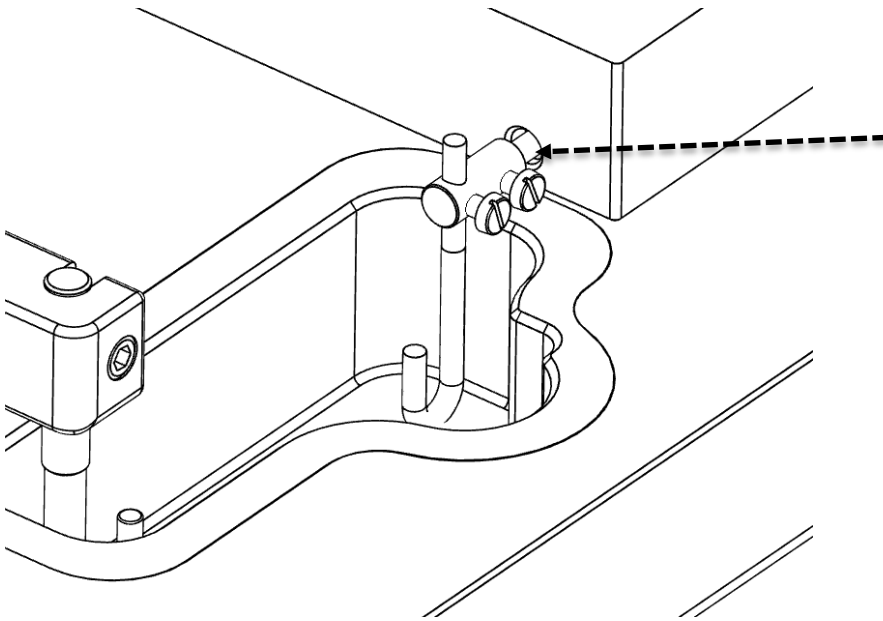


Figure 4.1 Close-up of transducer pin from outside. The arrow indicates where the grease is placed to seal the transducer pinhole.

4.2.1 CHECKING THE FORCE TRANSDUCER

The force transducer is a strain gauge connected to a Wheatstone bridge. The force transducers for each chamber are housed in a separate protective compartment. While the protective cover offers some mechanical protection for the force transducers, they are still very vulnerable to applied forces exceeding 1 Newton (100 grams) or fluid running into the transducer compartment due to insufficient greasing of the transducer pinhole.

If the force readings on the Multi Interface appear unstable or noisy, first check that the chambers are correctly connected to the Multi Interface and that the chambers are plugged into the Multi Interface. If the force reading(s) is still unstable or noisy, perform a new calibration described in chapter 3.2 in the Organ Bath System User Manual.

During the new calibration, monitor the relative force reading values in the Force Calibration sub-menu on the Multi Interface (Steps 4 and 5 of the force calibration procedure). The normal operating values for the force transducer during calibration should be between 3000 and 3500.

1. If the value is 0, a single digit, or a three-digit number, the force transducer is broken and needs to be replaced.
2. If the value is less than 1500 or greater than 4500, the force transducer is harmed and needs to be recompensated at DMT to work correctly. Contact your DMT sales representative.
3. If the message "OFF" is displayed on the main page of the Multi Interface, even though the Tissue Bath is plugged in at the rear of the Multi Interface, the force transducer is broken and needs to be replaced. In addition, if the force reading(s) appear yellow, cannot be reset to zero, AND the transducer cannot be recalibrated, the force transducer is broken and needs to be replaced.

If any other problems related to the force transducer are encountered, please get in touch with DMT for advice or further instructions.

4.2.2 FORCE TRANSDUCER REPLACEMENT

If the force transducer breaks and needs to be replaced, follow this step-by-step replacement procedure carefully:

1. Remove the pin from the transducer pin coming out of the transducer house.
2. Disconnect the Tissue Bath from the Multi Interface.
3. Turn the Tissue Bath upside down and remove the transducer housing by loosening the two screws, "A" and "B," as illustrated in figure 4.2 below.
4. The replacement transducer will be shipped with the new transducer inside a new transducer house.
5. Place a small amount of vacuum grease (clear or whitish) around the bottom of the transducer housing to seal the transducer housing when set back in place.
6. Carefully realign the transducer housing with the new transducer on the Tissue Bath and reinsert the Allen screws through the bottom of the Tissue Bath.
 - Tighten the screws and place some vacuum grease around the transducer pin that protrudes from the transducer housing, see figure 4.3. Ensure the hole is completely sealed to prevent buffer solution or water from entering the transducer housing and damaging the new force transducer.

IMPORTANT NOTE

CALIBRATE THE NEW FORCE TRANSDUCER BEFORE PERFORMING A NEW EXPERIMENT

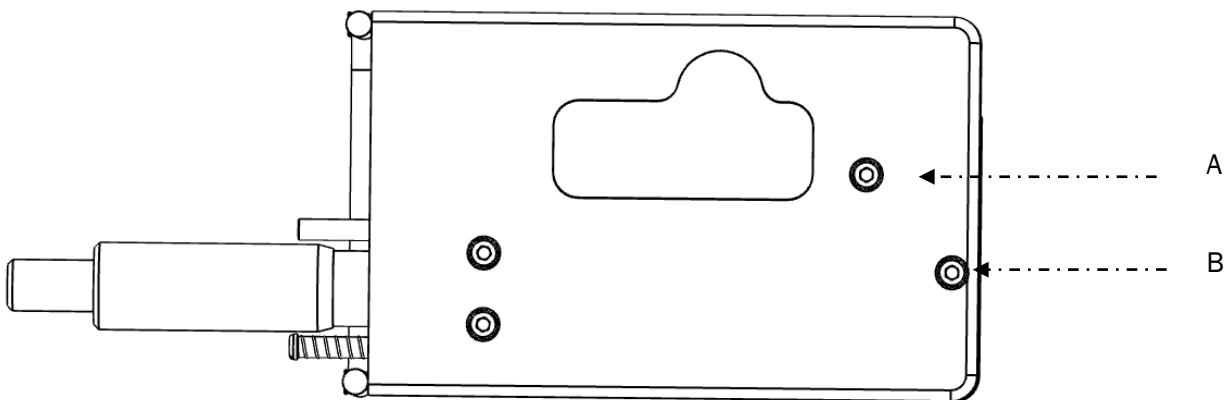


Figure 4.2 The two screws that secure the transducer house to the unit.

4.2.3 MAINTENANCE OF THE LINEAR SLIDES

Check the micropositioner for grease at least once a month. Three main parts will need to be greased on the micropositioner, those parts being the micropositioner screw thread and the two slide bars to the left and right of the micropositioner screw thread. In case of insufficient lubrication, grease the micropositioner with the "Grease for Linear Slides" included with your system. Apply the linear slide grease in the areas indicated by the arrows in figure 4.6 below.

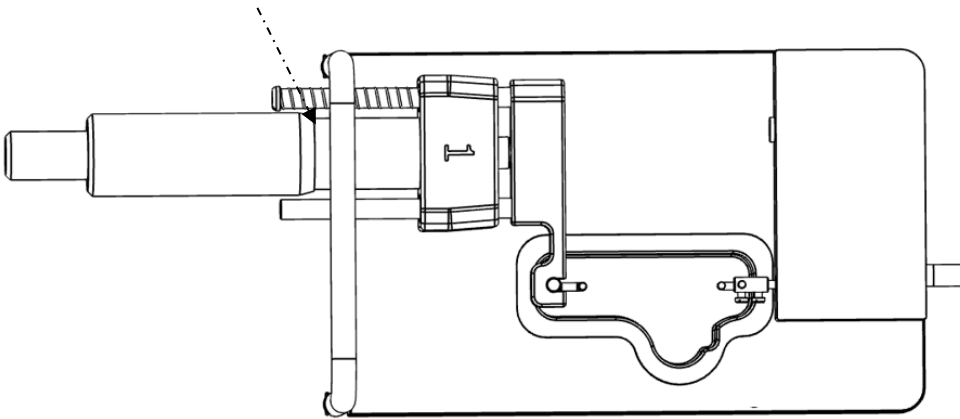


Figure 4.6 The areas where linear slide grease may be applied for smooth micropositioner movement.

APPENDIX 1 - BUFFER RECIPES

PHYSIOLOGICAL SALINE SOLUTION (PSS)

1X PSS:

Chemical	Mol. Wt	mM	g/0.5L	g/L	g/2L	g/4L
NaCl	(58.45)	130	3.799	7.598	15.20	30.39
KCl	(74.557)	4.7	0.175	0.35	0.70	1.40
KH ₂ PO ₄	(136.09)	1.18	0.08	0.16	0.32	0.64
MgSO ₄ 7H ₂ O	(246.498)	1.17	0.145	0.29	0.58	1.16
NaHCO ₃	(84.01)	24.9	1.05	2.10	4.18	8.37
Glucose	(180.16)	5.5	0.5	1.00	2.00	4.00
EDTA	(380)	0.026	0.005	0.01	0.02	0.04
CaCl ₂	(110.99)	1.6	0.8mL	1.6mL	3.2mL	6.4mL

- Make a 1.0M solution of CaCl₂ (110.99) in double-distilled H₂O. Filter-sterilize the calcium solution through a 0.22µm filter. The sterilized solution can be stored in the refrigerator for up to 3 months.
- Dissolve all the chemicals except the CaCl₂ in approximately 80% of the desired final volume of double-distilled H₂O while constantly stirring. For example, if 1 liter of PSS is to be made, dissolve all the chemicals in 800mL of double-distilled H₂O.
- Add the appropriate volume of 1.0M CaCl₂ for the total PSS volume (for example, 1.6mL of 1.0M CaCl₂ for 1 liter of buffer). Continue to stir the PSS while the CaCl₂ is being added.
- Bring the solution up to the final volume with double-distilled H₂O. Continue to stir the solution until the EDTA is fully dissolved. It takes about 15 minutes at room temperature.
- Aerate the solution with carbogen (95% O₂ + 5% CO₂) for about 20 minutes.

25X CONCENTRATED PSS:

Chemical	Mol. Wt	mM	g/0.5L	g/L	g/2L	g/4L
NaCl	(58.45)	3250	94.98	189.96	379.92	759.84
KCl	(74.557)	117.5	4.375	8.75	17.5	35.0
KH ₂ PO ₄	(136.09)	29.5	2.0	4.0	8.0	16.0
MgSO ₄ 7H ₂ O	(246.498)	29.25	3.625	7.25	14.5	29.0
EDTA	(380)	0.65	0.125	0.25	0.50	1.0

1. Make a 1.0M solution of CaCl₂ (110.99) in double-distilled H₂O. Filter-sterilize the calcium solution through a 0.22µm filter. The sterilized solution can be stored in the refrigerator for up to 3 months.
2. Dissolve all the chemicals in approximately 80% of the desired final volume of double-distilled H₂O while constantly stirring. For example, if 1 liter of PSS is to be made, dissolve all the chemicals in 800mL of double-distilled H₂O.
3. Bring the solution up to the final volume with double-distilled H₂O. Continue to stir the solution until the EDTA is fully dissolved. It takes about 15 minutes at room temperature.
4. Store cold before use.

Before use:

5. Dilute the 25 x PSS stock solution 1:25 using double distilled H₂O.
6. Add:
1.091g/L Glucose
2.100g/L NaHCO₃
7. Add the appropriate volume of 1.0M CaCl₂ for the total volume of PSS being made (for example, 1.6mL of 1.0M CaCl₂ for 1 liter of buffer). Continue to stir the PSS while the CaCl₂ is added.
8. Bring the solution up to the final volume with double-distilled H₂O. Aerate the solution with carbogen (95%O₂ + 5%CO₂) for at least 20 minutes. If necessary, wait further for the pH of the buffer to reach pH 7.4.

HIGH POTASSIUM PHYSIOLOGICAL SALINE SOLUTION (KPSS)

1x 60mM KPSS:

Chemical	Mol. Wt	mM	g/0.5L	g/L	g/2L	g/4L
NaCl	(58.45)	74.7	2.18	4.37	8.73	17.46
KCl	(74.557)	60	2.24	4.47	8.95	17.89
KH ₂ PO ₄	(136.09)	1.18	0.08	0.16	0.32	0.64
MgSO ₄ ·7H ₂ O	(246.498)	1.17	0.145	0.29	0.58	1.16
NaHCO ₃	(84.01)	24.9	1.05	2.10	4.18	8.37
Glucose	(180.16)	5.5	0.5	1.00	2.00	4.00
EDTA	(380)	0.026	0.005	0.01	0.02	0.04
CaCl ₂	(110.99)	1.6	0.8mL	1.6mL	3.2mL	6.4mL

1. Make a 1.0M solution of CaCl₂ (110.99) in double-distilled H₂O. Filter-sterilize the calcium solution through a 0.22µm filter. The sterilized solution can be stored in the refrigerator for up to 3 months.
2. Dissolve all the chemicals except the CaCl₂ in approximately 80% of the desired final volume of double-distilled H₂O while constantly stirring. For example, if 1 liter of PSS is to be made, dissolve all the chemicals in 800mL of double-distilled H₂O.
3. Add the appropriate volume of 1.0M CaCl₂ for the total PSS volume (for example, 1.6mL of 1.0M CaCl₂ for 1 liter of buffer). Continue to stir the PSS while the CaCl₂ is being added.
4. Bring the solution up to the final volume with double-distilled H₂O. Continue to stir the solution until the EDTA is fully dissolved. It takes about 15 minutes at room temperature.
5. Aerate the solution with carbogen (95% O₂ + 5% CO₂) for about 20 minutes.

APPENDIX 2 - NORMALIZATION THEORY FOR VESSELS

The importance of making a normalization before initiating an experiment with any tubular tissue segment is described in chapter 3.2. In this appendix, the mathematical rationale and calculations underlying the normalization procedure are described in detail.

MATHEMATICAL CALCULATIONS

Let (X_i, Y_i) be the pair of values representing the micrometer reading (see Appendix 3) and force reading characterizing each step in the normalization procedure. Y_0 is the force reading at the start position of the normalization procedure where the wires are just separated, and the force reading is approximately zero. Then, given that tension on the vessel is equal to force divided by wall length, the wall tension at the i -th micrometer reading is calculated by:

$$T_i = \frac{(Y_i - Y_0)}{2\delta \cdot (a_1 - a_2)}$$

where δ is the microscope eyepiece reticule calibration factor in mm per division, and a_1 , and a_2 are the vessel endpoints when measuring the length of the mounted vessel segment.

The internal circumference of the mounted vessel at the i -th reading is calculated by:

$$IC_i = IC_0 + (2 \cdot (X_i - X_0))$$

where IC_0 is the internal circumference of the mounted vessel when the wires are just separated and is given by:

$$IC_0 = (2 + \square) \cdot d$$

where d is the wire diameter. For 40 μm wires, $IC_0 = 205.6 \mu\text{m}$.

The effective pressure P_i is calculated for each pair of readings using the Laplace relation. The effective pressure is an estimate of the internal pressure, which is necessary to extend the vessel to the measured internal circumference.

$$P_i = \frac{T_i}{\left(\frac{IC_i}{2\pi}\right)}$$

The stepwise distension is continued until the calculated effective pressure exceeds the target transmural pressure. The target value needs to be optimized for the individual tissue preparation (optimal active force as determined by the length-tension relationship for that tissue). For rat mesenteric arteries, the target transmural pressure is normally 100mmHg (13.3kPa):

$$T_{100 \text{ mmHg}} = 100 \text{ mmHg} \cdot \left(\frac{IC}{2\pi}\right)$$

An exponential curve is fitted to the internal circumference pressure data as illustrated in figure 3.9. Now, the isobar corresponding to 100mmHg is used to calculate the IC_{100} value from the point of interception between the function of the exponential curve and the function of the 100mmHg isobar.

The normalized internal circumference IC₁ is calculated by multiplying the internal circumference corresponding to 100mmHg, IC₁₀₀, by a factor k. The factor is for rat mesenteric arteries 0.9. Again, this value should be optimized for the particular tissue preparation being used by a length-tension curve.

$$IC_1 = k \cdot IC_{100}$$

The normalized internal (lumen) diameter is then calculated by:

$$d_1 = \frac{IC_1}{\pi}$$

The micrometer reading X₁, at which the internal circumference of the normalized vessel is set, is calculated by:

$$X_1 = X_0 + \frac{(IC_1 - IC_0)}{2}$$

2²

APPENDIX 3 - READING A MILLIMETRE MICROMETER

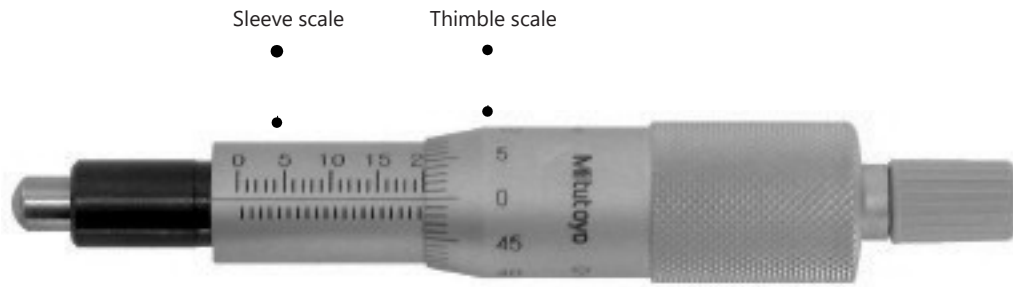


Figure A3.1 Overview of the micrometer parts (actual reading $20000\ \mu\text{m} = 20\ \text{mm}$).

Sleeve scale

The micrometer sleeve scale has a total length of 25mm divided into 50 equal parts. Each part of a division above the horizontal line represents 1mm, where each 5th line is marked by a longer line and a number designating the length in mm. Each division below the horizontal line is placed between each 1 mm mark (scale above the horizontal line) and represents 0.5mm.

Thimble scale

The thimble is divided into 50 equal parts, and one complete thimble rotation is indicated by the smallest division on the sleeve, which equals 0.5mm. Each division on the thimble scale is $10\ \mu\text{m}$. If the thimble scale falls between two lines, 0 and $10\ \mu\text{m}$ must be approximated.

Example 1

- Note that the thimble has stopped beyond "10" on the sleeve, indicating $10000\ \mu\text{m}$ (10mm).
- Note that no mark between the 10mm mark and the thimble is completely visible.
- Read the value on the thimble corresponding to the intersection with the horizontal line on the sleeve.

A. Reading on sleeve:	$10000\ \mu\text{m}$
B. No additional mark visible:	$0\ \mu\text{m}$
C. Thimble reading:	$380\ \mu\text{m}$
Total reading:	$10380\ \mu\text{m}$

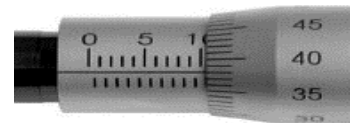


Figure A2.2 Example 1: reading = $10380\ \mu\text{m}$

Example 2

- Note that the thimble has stopped beyond "16" on the sleeve, indicating $16000\ \mu\text{m}$ (16mm).
- Note that a mark is visible this time between the 16 mm mark and the thimble indication $500\ \mu\text{m}$.
- Read the value on the thimble corresponding to the intersection with the horizontal line on the sleeve.

A. Reading on sleeve:	$16000\ \mu\text{m}$
B. One additional mark visible:	$500\ \mu\text{m}$
C. Thimble reading:	$280\ \mu\text{m}$
Total reading:	$16780\ \mu\text{m}$

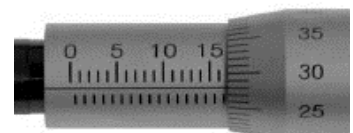


Figure A2.3 Example 2: reading = $16780\ \mu\text{m}$

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