

May 15, 2002
Torso Tank Experimental Report

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1 Introduction

This experiment has several complementary goals:

- Test for the first time the new cage electrode.
- Record both normal beats and those during and after occlusions from both cage and tank surface electrodes.
- Study the ischemia that results from variable flow ischemia via cannulation of the LAD and perfusion through a calibrated pump.

Where there are open questions, we use *italics* and ask that anyone reading this document see if they can provide any answers or suggestions.

2 To Do

1. Check the alignment of the rack and pinion frame with the digitizer. (Shibaji, Rob)
2. MUX mapping file: we need to create a new one for this (cage) electrode. (Rob)
3. Make sure pump, cannula, and tank are all ready to go (Matt, Bonnie)
4. Make sure the cage is ready and mapped out (Shibaji, Bruce, Jayne)

3 Protocol

3.1 General Plan

1. Perform first test experiments with the new cage electrode.

3.2 Setup details

3.2.1 Acquisition system

This experiment requires the 1024-lead acquisition system with the following configuration:

Torso tank: 192 lead subset (subset #1) for tank surface, with high gain settings (6 or 7).

Cage electrode: lead sock with lower gain settings (1 or 3)

Geometry measurements: Miniscribe 3D digitizer arm with table for the Andy III tank.

3.2.2 Anesthetic

As there is no special interest in repolarization nor any interventions to illicit variations in repolarization characteristics, we can use the standard sodium pentobarbital anesthetic.

3.2.3 Blood gases

Now that we have the new blood gas meter, we should use it to monitor blood gases and pH of the isolated heart and support animal.

We will take blood samples from a needle inserted (and left) in the tubing that enter the isolated heart every 30 minutes and test it for blood gases and pH.

3.3 Isolation procedure and application of stimulus and measurement electrodes

The isolation and electrode application will be according to the protocol Bonnie and Bruno developed for carrying out the cannulation of the LAD:

1. Before isolating the heart, expose a segment of LAD above the first diagonal branch and apply two threads around it;
2. Isolate the heart and secure it in the torso tank, with adequate time allowed for warming and securing the heart to the gantry;
3. Be careful not to tighten the screw on the cannula too tight (I have broken the cannula doing this!)
4. Attach an atrial pincher but no pacing needles;
5. Apply the cage electrode.
6. To apply occlusions, feed a piece of plastic or rubber tubing over the threads and slide the tubing to the vessel.
7. To insert the cannula:
 - (a) Make sure blood flow is established through the cannula
 - (b) Tie off the top snare
 - (c) Slice into the artery
 - (d) Insert the “flag”
 - (e) Slip a cannula through the flag
 - (f) Tie the cannula with the lower thread and ensure adequate flow through it (we assume a flow rate of 30 cc/min as a reasonable starting point).

3.4 Temperature measurements

We should use two probes in the digital thermometer, one in the tank and the other in the inflow path to the LAD cannula. In past experiments, there has been a difference of about 1.4–3° C between the two with the tank warmer.

3.5 Measurement protocol

3.5.1 Overview

1. Control recordings with pacing at four different sites:
atdr, LV needle #1, LV needle #2, and RV needle;
2. Apply occlusion using the usual sampling sequence with
 - (a) control recording before occlusion;
 - (b) occlusion of the snare, then record at 30 s post application of the snare;
 - (c) repeat recording at 60, 90, and 120 s;
 - (d) at 120 s release the snare;
 - (e) repeat measurements at 30, 60, 120, and 300 s after release of the occlusion;
 - (f) allow for 5 additional minutes for recovery before next cycle.
3. Elevate the heart and then digitize the tank reference points and the reference markers on the cage (see Section 3.5.2);

3.5.2 Geometry measurements

We have a new geometry to handle this time, a cage electrode array with about 600 nodes. Locating the cage in the tank, however, can occur with the same steps as for a sock:

1. Before the experiment, align the tank supports to be in the same vertical axis as the digitizer.
2. After the experiment, digitized the usual tank reference points.
3. After lifting the heart from the tank to get access, digitize a set of reference markers on the cage, which we still have to define.

3.5.3 Imaging

As part of the BISTI grant we (Ed and EK) will also image these hearts in the MRI machine so we should plan on injecting contrast agent (Omniscan, gadolinium) and packing the hearts in formalin after every experiment in which we perform any manipulation of flow.

3.6 MUX mapping and channels

We need a new mapping file for the cage, which will follow the andy3 leads in the MUX.

4 Notes from the Experiment

10:30–12:00 Problems with clotting in the plumbing so we had to replace all the tubing and then start again

11:50 isolated the heart.

12:00 cleaned up heart and started to prepare for cage mounting.

13:30 finally got the cage on and everything wired; we applied a nylon stocking to the heart to help it from flopping around and there was only just enough space inside the cage for the heart; this was a good sized heart compared to most we get, but next time, the cage could be shorter and rounder, *i.e.*, less cylindrical in shape. We opened and shut the cage a few times in the process and it fit very well with the existing hardware for the heart with each mounted on its own clamp (see photos).

13:45 first set of control recordings with the following pacing needles applied

- Pacing 1: left ventricular electrode #1
- Pacing 2: LV electrode #2
- Pacing 3: RV electrode

We needed a lot of current to pace the heart; it would otherwise not capture and threw many PVCs throughout the experiment.

14:05 OCL1: first occlusion, which we did the usual sequence and stimulated from the Pacing 1 site. There was a delay in the 120 s and the 150 s recording of about 20 s but after that we got back on schedule. **Note: all these beats got mislabelled as atrd in the data files. They are LV1 paced.**

14:15 OCL2: same sequence but we lost pacing control at 120 s; subsequent recordings are not worth processing.

14:30 OCL3: we tried LV2 pacing for this one at electrodes 6 & 7 and had fewer problems, but still lost pacing in the end. The recording at 180 s will have some good beats but also some bad. We could not capture at 240 s so this run may be absent from the sequence. The 300 s sample occurred at 360 s and the 420 s sample was valid, on time, but with PVCs to watch out for.

14:55 we noticed problems at the end of the last occlusion sequence with blood pressure dropping to 30 mm and could not keep the support dog alive. The problem was not clear, perhaps an overdose of anesthesia, but the techs found eye responses that worried them and so they applied more anesthesia than otherwise.

15:05 recorded cals with the following settings:

	B1	B2	B3	B4	B5	B6	B7	B8
Master	5	5	5	5	1	1	1	1
Slave	2	2	2	2	2	2	2	2

15:15 Geometry: we measured the tank refs and reference points on the cage, as described below.

4.1 Blood gases

There were three blood gas measurements:

12:05, 13:06, and 13:58 and they showed pH of 7.4, 7.4, and 7.35; pO₂ of 60, 59, and 69 with pCO₂ of 16, 16, and 13. So nothing that would suggest big problems with the support dog.

4.2 Temperature measurements

None noted.

4.3 Geometry

We did all the usual geometry measurements, but with some new reference points on the cage. See Section 7 below for details.

5 To check for next time

1. Maintenance of tank temp; we started a little low (34C) and it took ages to get it up to even 35. The problem seems to be in the bath that we share between tank heat exchanger and other heater lines for the blood too and from the isolated heart. Could we not use a second bath?
2. When applying th cage, make sure to first attach the atrial pacing hook and any needles.
3. Make sure we write down and photograph the layout of the connectors for the MUX; once again, we had confusion about the MUX mapping because we left one input empty in the first bank after the 192 tank leads before going to the cage. This is fine as long as we make note of it and accommodate in the muxmapping file.
4. Make sure to print blood gas results as we collect them—it does not appear to be possible to recall old ones.
5. Make sure to measure the alignment of the gantry before the experiment so that our geometry is accurate.
6. Heparin is our friend, use it plentifully!

6 MUX mapping and channels

The mix mapping for this experiment took a little fiddling, in part because this was the first time with the cage and in part because we left one input open in the MUX. I was able to make an addition to the muxmapping program to create a proper file; it just took a couple tries and Jeroen's tinkering with different possibilities. So see the makemuxmapping program and try making a file with the command

```
makemuxmapping.sh -t 192 -s 610 -m 1024
or for the full mux mapping file
makemuxmapping.sh -t 192 -s 610 -m 1024 -f
```

7 Geometry

Here is the .ms file we got from the geomwtry.

FILE NAME: cagerefpts.ms LAST MODIFIED: Wednesday, May 15, 2002 4:04:47 PM

Measurements are in millimeters

```
*****
tankref 0 0.000 0.000 0.000
tankref 1 134.731 221.720 -157.705
tankref 2 112.287 219.230 -168.330
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tankref 3 102.246 187.645 -167.708
tankref 4 93.088 188.520 -190.187
tankref 5 112.122 155.435 -167.205
tankref 6 101.850 150.450 -189.794
tankref 7 125.528 120.075 -167.696
tankref 8 117.403 115.127 -189.344
tankref 9 137.087 88.273 -166.453
tankref 10 129.730 79.215 -188.224
tankref 11 149.113 47.443 -164.899
tankref 12 142.190 42.683 -187.286
tankref 13 171.273 16.005 -164.353
tankref 14 166.191 9.580 -186.605
tankref 15 200.245 1.211 -163.900
tankref 26 284.088 55.236 -166.703
tankref 27 235.442 12.209 -151.762
tankref 28 265.648 24.454 -152.649
tankref 25 166.702 229.392 -156.281
cageref F1 243.183 137.991 39.267
cageref F2 244.100 138.581 30.291
cageref F3 244.592 137.315 20.697
cageref F4 244.427 136.837 11.480
cageref F5 245.461 136.110 3.060
cageref F6 246.057 135.619 -7.875
cageref F7 245.114 135.928 -19.020
cageref B1 149.666 140.990 36.891
cageref B2 146.676 139.681 27.668
cageref B3 147.419 139.662 16.410
cageref B4 147.898 139.448 8.103
cageref B5 148.357 138.253 -1.891
cageref B6 149.218 139.629 -10.454
cageref B7 150.259 139.220 -23.072
cageref B8 150.418 138.565 -31.480
cageref B9 152.102 138.091 -43.190
Red 174.031 143.471 44.414
Green 196.839 155.701 41.623
cage-bot 8 192.950 175.585 -107.726
cage-bot 9 185.373 174.189 -108.423
cage-bot 10 179.903 170.255 -110.665
cage-bot 11 173.700 166.580 -110.445
cage-bot 12 167.682 160.521 -110.040
endoffile

```

“Red” and “Green” are points on the top of the cage that we marked previously as the first and fourth electrode locations.

F1–F7 are points on the front junction of the two cage halves on the left side of the junction, as view from the outside, starting from the top of the cage. The B1–B9 points are from the back hinged coupling of the two halves on the right side of the junction as view from the outside, and again starting from the top of the cage.

From looking at the geometry, these points correspond as follows:

Cage reference points	
Cage reference	Cage node #
F1	
2F	
F3	
F4	
F5	
F6	
F7	
B1	
B2	
B3	
B4	
B5	
B6	
B7	
B8	
B9	
Red	
Geen	
8	
9	
10	
11	
12	

Steps in making an aligned cage/tank geometry:

1. Copied **tankrefs-all.pts** and a 490 sock with 5 reference points (**490sock-5align.pts**) to the local directory.
2. Converted the .ms file to .pts file with all the reference points using digtoxyz. Note that all ref points were in the file, but only a subset at tankref points, so I called the file **tanksockoliverefs.pts**
3. Set up a file to link the points in **tankrefs-all.pts** to those in **tanksockoliverefs.pts**. Note the order of each entry pair has to be point from the fixed file and then point from the rotated (or rotateable) file. I called this **tankrefs.leadlinks**
4. Ran align on the two file to align all the reference points to the tank space. Generated the file **tanksockoliverefs_aligned.pts**.
5. Made another links file to tell me where the nodes in the **tanksockoliverefs_aligned.pts** line up with the five reference points in the 490+5 pts file. Note the order can be tricky here.
6. Ran align on the 490 sock file to align it according to the five reference points and made the tile **490sock-5align_aligned.pts**. Strip the five extra points way from this and we should have the final, aligned 490 sock nodes in **490sock_aligned.pts**. Copied a .fac file and we have our geometry for the sock and tank.

8 Data Files

8.1 Acquisition Files

Number	Header	Time
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8.2 TSDF files

8.2.1 Full time series

# Filename	Header
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8.2.2 Integral Files

# Filename	Header
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8.3 TSDFC files

9 Analysis