

Submission ID #: 72336

Scriptwriter Name: Pallavi Sharma

Project Page Link: https://review.jove.com/files_upload.php?src=22062528

Title: Precision Ligation of the Left Anterior Descending Coronary Artery Using Anatomical Landmarks in a Murine Myocardial Infarction Model

Authors and Affiliations:

Linshen Mao^{*1,2}, Houping Xu^{*1,2}, Yan Wei^{*3}, Li Dong^{1,2}, Jinhui Jiang^{1,4}, Qingyu Zhang^{1,4}, Ping Liu^{1,4}, Zhenzhou Li^{1,4}, Mengnan Liu^{1,2}, Gang Luo^{1,2}

¹Department of Cardiovascular Medicine, Affiliated Traditional Chinese Medicine Hospital

²National Traditional Chinese Medicine Clinical Research Base, Affiliated Traditional Chinese Medicine Hospital

³Key Laboratory of Medical Electrophysiology, Ministry of Education & Medical Electrophysiological Key Laboratory of Sichuan Province (Collaborative Innovation Center for Prevention of Cardiovascular Diseases)

⁴School of Integrated Traditional and Western Medicine, Southwest Medical University

* These authors contributed equally

Corresponding Authors:

Mengnan Liu (liumengnan@swmu.edu.cn)
Gang Luo (luogang1982@swmu.edu.cn)

Email Addresses for All Authors:

Linshen Mao	(maolinshen@swmu.edu.cn)
Houping Xu	(xuhpswmu@163.com)
Yan Wei	weiyan.1111@swmu.edu.cn
Li Dong	(xiaodongluyi@swmu.edu.cn)
Jinhui Jiang	(20210314330331@stu.swmu.edu.cn)
Qingyu Zhang	(20200315330108@stu.swmu.edu.cn)
Ping Liu	(helloliuping@swmu.edu.cn)
Zhenzhou Li	(20220315330129@stu.swmu.edu.cn)
Mengnan Liu	(liumengnan@swmu.edu.cn)
Gang Luo	luogang1982@swmu.edu.cn

Author Questionnaire

1. Microscopy: Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **Yes**

No

If your microscope does not have a camera port, the scope kit will be attached to one of the eyepieces and **you will have to perform the procedure using one eye.**

Maishidi (Dongguan) Technology Co., Ltd. MSD204

3.3.2, 3.4.2, 3.5.1, 3.5.2, 4.1.2, 4.2.1, 4.2.2, 4.3.1, 4.3.2, 4.4.1, 4.4.2, 4.5.1

Videographer: Please film all shots labeled as SCOPE using the scope kit

2. Software: Does the part of your protocol being filmed include step-by-step descriptions of software usage? **No**

3. Filming location: Will the filming need to take place in multiple locations? **No**

4. Testimonials (optional): Would you be open to filming two short testimonial statements **live during your JoVE shoot?** These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **No**

Current Protocol Length

Number of Steps: 24

Number of Shots: 50

Interviews

Videographer: Obtain headshots for all authors available at the filming location.

INTRODUCTION:

~~REQUIRED: Summarize your research focus and the main questions it aims to answer.~~

- 1.1. **Mengnan Liu:** We investigate myocardial infarction in mice, examining how to position the coronary ligation consistently for reliable preclinical results.
 - 1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.
File name: 1.1 **Timestamps:** 00:00 – 00:14

~~Describe the research gap or limitation in existing methods and how this protocol addresses them.~~

- 1.2. **Mengnan Liu:** Conventional coronary ligation is inconsistent and operator-dependent; using the anterior interventricular sulcus provides a reproducible landmark that improves procedural consistency.
 - 1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B roll: 4.1.2*
File name: 1.2 **Timestamps:** 00:00 – 00:15

CONCLUSION:

~~Describe the most important consideration or challenge when performing this protocol.~~

- 1.3. **Mengnan Liu:** The greatest challenge while performing this protocol is identifying the anterior interventricular sulcus, because it determines exactly where the ligature is placed.
 - 1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B roll: 4.2.2*
File name: 1.3 **Timestamps:** 00:00 – 00:15

~~Are there any additional methods or analyses that can be performed following this procedure?~~

1.4. **Mengnan Liu:** This model supports electrocardiography, echocardiography, serum biomarker assays, histological staining, and so on.

1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

File name: 1.4 **Timestamps:** 00:00 – 00:13

~~How can future studies build on this work? Describe the questions or research directions that can be investigated next.~~

1.5. **Mengnan Liu:** Future studies should characterize how the anterior interventricular sulcus relates to the underlying artery across larger cohorts and other species.

1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

File name: 1.5 **Timestamps:** 00:00 – 00:15

Videographer: Obtain headshots for all authors available at the filming location.

Ethics Title Card

This research has been approved by the Institutional Animal Care and Use Committee (IACUC) at the Animal Experiment Center of Southwest Medical University.

Protocol

***Videographer:** Please always record an audio slate while filming each shot mentioned in the shotlist.*

2. Pre-surgical Preparation and Tracheal Intubation

Demonstrator: Linshen Mao

- 2.1. After preparing the instrument and setting up the working station, apply the depilatory cream to the thoracic region of mice for 1 minute [1]. Using sterile gauze moistened with sterile water or saline, remove the cream and hair gently [2].
 - 2.1.1. WIDE: Talent applying the depilatory cream to the thoracic region.
 - 2.1.2. Talent removing the cream and hair using sterile gauze moistened with sterile water or saline.
- 2.2. One hour before surgery, administer cefazolin at 300 milligrams per kilogram by intraperitoneal injection [1].
 - 2.2.1. Talent administering cefazolin by intraperitoneal injection.
- 2.3. Position the anesthetized mouse in the supine position on the murine tracheal intubation platform [1-TXT]. Suspend the mouse by hooking the upper incisors onto the platform's rubber band, then extend the head and neck to approximately 45 degrees [2]. Align the oral, pharyngeal, and laryngeal axes to bring the glottis into direct view [3].
 - 2.3.1. Talent positioning the anesthetized mouse on the murine tracheal intubation platform. **TXT: Anesthesia: 3.5%–4.0% Isoflurane; Flow rate: 0.5 L/min**
 - 2.3.2. Talent suspending the mouse by hooking the upper incisors onto the platform's rubber band.
 - 2.3.3. Talent aligning the oral, pharyngeal, and laryngeal axes to visualize the glottis.
- 2.4. Then, using forceps, open the mouth and gently displace the tongue to one side [1]. Insert the blade of a small-animal laryngoscope along the dorsum of the tongue and depress the base of the tongue [2].
 - 2.4.1. Talent opening the mouse's mouth and displacing the tongue to one side with forceps.
 - 2.4.2. CU: Talent inserting the small-animal laryngoscope along the dorsum of the tongue and depressing the base of the tongue.
- 2.5. Advance the laryngoscope until the epiglottis is visible [1]. Lift the laryngoscope upward and forward along the axis of the handle to elevate the epiglottis and expose the V-shaped glottic opening and the pale vocal cords [2].

- 2.5.1. Talent advancing the laryngoscope and showing epiglottis.
- 2.5.2. Talent lifts the laryngoscope and exposes the V-shaped glottic opening and the pale vocal cords. **NOTE: This shot will be filmed together with Shot 2.5.1.)**
- 2.6. Then, advance the catheter through the open glottis during inspiration while maintaining direct visualization of the vocal cords [1]. Remove the laryngoscope after the catheter passes through the glottis [2].
 - 2.6.1. Talent advancing the catheter through the open glottis while the vocal cords remain in direct view.
 - 2.6.2. Talent removing the laryngoscope after the catheter passes through the glottis.
- 2.7. Next, advance the catheter to a depth of approximately 5 to 7 millimeters [1]. Then, withdraw the stylet [2] and connect the catheter to the ventilator [3].
 - 2.7.1. Talent advancing the catheter to a depth of approximately 5 to 7 millimeters.
 - 2.7.2. Talent withdrawing the stylet from the catheter. **NOTE: This shot will be filmed together with Shot 2.7.1.)**
 - 2.7.3. Talent connecting the catheter to the ventilator.
- 2.8. After confirming successful tracheal intubation, deliver air as the carrier gas at a flow rate of 0.5 liters per minute and maintain anesthesia with 1.5 to 2.0% isoflurane [1]. Set the ventilator to a respiratory rate of 130 breaths per minute, a tidal volume of 2 milliliters, and an inspiratory-to-expiratory ratio of 5 to 4 [2]. Continuously monitor anesthesia depth and physiological parameters, adjusting isoflurane as needed and pausing the procedure until stable conditions are restored [3].
 - 2.8.1. Talent placing the catheter into the ventilator circuit.
 - 2.8.2. Talent setting the respiratory rate, tidal volume, and inspiratory-to-expiratory ratio.
 - 2.8.3. Talent checking anesthesia depth and the physiological parameters.
- 2.9. Tilt the mouse toward the right side with the left side uppermost to expose the left thoracic wall [1]. Using adhesive tape, secure the four limbs and tail to the platform [2].
 - 2.9.1. Talent tilting the mouse toward the right side with the left side uppermost.
 - 2.9.2. Talent securing the four limbs and tail to the platform with adhesive tape.
- 2.10. Then, disinfect the surgical site with three successive applications of povidone–iodine [1].
 - 2.10.1. Talent disinfecting the surgical site with povidone–iodine using three successive applications.

3. Thoracotomy and Heart Exposure

- 3.1. Using ophthalmic scissors, make a 1-centimeter longitudinal skin incision on the left thoracic wall parallel to the long axis of the sternum and approximately 2 millimeters lateral to the left sternal border [1]. Expose the underlying pectoral muscles [2].
 - 3.1.1. Talent making a 1 centimeter longitudinal skin incision on the left thoracic wall using ophthalmic scissors.
 - 3.1.2. Talent exposing the underlying pectoral muscles.
- 3.2. Using fine forceps, bluntly separate the pectoralis major and pectoralis minor muscles along the direction of their fibers [1]. Retract the muscles laterally to expose the ribs and intercostal spaces and avoid cutting the muscles to minimize bleeding [2].
 - 3.2.1. CU: Talent bluntly separating the pectoralis major and pectoralis minor muscles using fine forceps.
 - 3.2.2. CU: Talent retracting the muscles laterally to expose the ribs and intercostal spaces.
- 3.3. Identify the appropriate intercostal space before opening the thoracic cavity [1]. Locate the anterior intercostal artery, a branch of the internal thoracic artery that courses within an intercostal space parallel to the ribs [2]. Then, identify the third intercostal space immediately cranial to the most consistently visible artery in the fourth intercostal space [3].
 - 3.3.1. CU: Talent shows the intercostal space.
 - 3.3.2. SCOPE: Shot of the anterior intercostal artery coursing parallel to the ribs.
Videographer: Please film all shots labeled as SCOPE using the scope kit
 - 3.3.3. CU: Shot highlighting the third intercostal space immediately cranial to the artery in the fourth intercostal space.
- 3.4. Next, perform a thoracotomy through the left third intercostal space [1]. Using a V-shaped eyelid retractor, gently spread the intercostal space until the left atrial appendage and the upper one-third of the left ventricle are clearly exposed within the surgical field [2].
 - 3.4.1. Talent performing a thoracotomy through the left third intercostal space.
 - 3.4.2. SCOPE: Talent spreads the intercostal space with a V-shaped eyelid retractor and exposes the left atrial appendage and the upper one-third of the left ventricle.
- 4.1A Pass a 6-0 nylon suture through the chest wall and apply gentle traction to widen the operative field [1]. **NOTE: This shot is moved here as per author request**
 - 4.1.1. Talent passing a 6-0 nylon suture through the chest wall and applying gentle traction to widen the operative field.

- 3.5. Using one pair of fine forceps, gently grasp the pericardium and lift it away from the myocardium [1]. Using a second pair of fine forceps, tear the pericardium open slowly to completely expose the heart [2].

3.5.1. SCOPE: Talent grasping the pericardium with one pair of fine forceps and lifting it away from the myocardium.

3.5.2. SCOPE: Talent tearing the pericardium open with a second pair of fine forceps to completely expose the heart.

4. Landmark-Guided Ligation of the Left Anterior Descending (LAD) Coronary Artery

- 4.1 B ~~Pass a 6-0 nylon suture through the chest wall and apply gentle traction to widen the operative field [1].~~ Expose the anterior interventricular sulcus or AIS (A-I-S) completely before identifying the ligation site [2].

~~4.1.1. SCOPE: Talent passing a 6-0 nylon suture through the chest wall and applying gentle traction to widen the operative field. (This shot will be filmed without the microscope and will be moved to immediately before Shot 3.5.1.)~~ NOTE: This shot is moved before 3.5.

4.1.2. Talent exposing the anterior interventricular sulcus completely. NOTE: This shot was filmed using the SCOPE setup.)

- 4.2. Identify the AIS as the shallow groove running obliquely from the cardiac base toward the apex and marking the surface boundary between the left and right ventricles [1]. Under the microscope, identify the AIS as a quasi-circular depression located approximately 1 to 2 millimeters below the inferior margin of the left atrial appendage [2].

4.2.1. SCOPE: Shot of the anterior interventricular sulcus visible as a shallow groove extending from the cardiac base toward the apex. Authors: Please use a pointer to show AIS

4.2.2. SCOPE: Shot of AIS visible as a quasi-circular depression approximately 1 to 2 millimeters below the inferior margin of the left atrial appendage.

- 4.3. Identify the approximate ligation site across the groove at the superior third of the AIS [1]. Then, pass a 7-0 nylon suture across the groove, inserting the needle perpendicular to the epicardial surface to a depth of approximately 0.5–1 millimeter, with the entry and exit points on opposite sides of the groove spanning its maximal width. [2].

4.3.1. SCOPE: Talent passing a 7-0 nylon suture across the groove at the superior third of the anterior interventricular sulcus. NOTE: Talent using forceps to indicate the approximate ligation site at the superior third of the anterior interventricular sulcus (AIS).)

4.3.2. SCOPE: Talent inserting the needle perpendicular to the epicardial surface with the entry and exit points spanning the maximal width of the groove.

- 4.4. Secure the ligature using a surgeon's knot [1]. Then, adjust the ligature until immediate blanching of the myocardium distal to the ligation site occurs after the first throw without appreciable local tissue indentation [2].
 - 4.4.1. SCOPE: Talent securing the ligature with a surgeon's knot.
 - 4.4.2. SCOPE: Shot of the myocardium distal to the ligation site showing immediate blanching without appreciable local tissue indentation.
- 4.5. Confirm successful coronary occlusion within 1 minute of ligation by observing patchy ischemic blanching of the myocardium distal to the ligation site [1].
 - 4.5.1. SCOPE: Shot of the myocardium distal to the ligation site showing patchy ischemic blanching within 1 minute after ligation.

5. Closure and Postoperative Recovery

- 5.1. Carefully remove the V-shaped eyelid retractor [1]. Close the thoracotomy with a single interrupted 5-0 nylon suture, passing the needle around the third and fourth ribs to re-approximate the third intercostal space [2]. Before tying the suture, gently compress the thorax at end-expiration to evacuate residual intrathoracic air, then maintain compression while securing the suture with a surgeon's knot [3]. NOTE: The VO is edited for the deleted shot
 - 5.1.1. Talent removing the V-shaped eyelid retractor.
 - 5.1.2. Talent closing the thoracotomy with a single interrupted 5-0 nylon suture around the third and fourth ribs.
 - ~~5.1.3. Close up of the needle passing close to the rib surface while avoiding the intercostal neurovascular bundle. (This step was deleted.)~~ NOTE: Not filmed
 - 5.1.4. Talent maintaining thoracic compression while securing the suture with a surgeon's knot.
- 5.2. Ensure complete apposition of the wound edges and close the skin incision in layers using 5-0 nylon sutures. [1].
 - 5.2.1. Talent closing the skin incision in layers using 5-0 nylon sutures.
- 5.3. Place the mouse on a temperature-controlled heating pad at 37 degrees Celsius [1]. Discontinue isoflurane administration and continue mechanical ventilation until spontaneous respiration resumes [2]. Observe the animal for recovery from anesthesia, including movement of the tail or whiskers and restoration of a regular respiratory pattern of approximately 150 breaths per minute [3].
 - 5.3.1. Talent placing the mouse on a temperature-controlled heating pad.
 - 5.3.2. Talent discontinuing isoflurane administration.
 - 5.3.3. Shot of the mouse showing tail or whisker movement and a regular spontaneous respiratory pattern during recovery.

- 5.4. After recovery, perform ECG assessment, histological analysis, and three-dimensional coronary artery imaging [1].
 - 5.4.1. Talent in front of the computer, scrolling through the images of the mentioned procedures.

Results

6. Results

- 6.1. After left anterior descending or LAD (*Lad*) ligation, notable ECG changes included deepening Q-waves, upward convex ST-segment elevation, peaked hyperacute T-waves, increased QRS complex voltage, and pronounced tachycardia [1].
 - 6.1.1. LAB MEDIA: Figure 3A. *Video editor: Highlight MI ECG and compare with NC*
- 6.2. Gross examination demonstrated localized myocardial blanching and ventricular dilatation distal to the ligation site in the myocardial infarction or MI (*M-I*) group compared with the control group [1].
 - 6.2.1. LAB MEDIA: Figure 3B. *Video editor: Highlight the heart labelled "MI" and compare it with NC*
- 6.3. Histopathological examination showed disorganized myocardial fibers, widened intercellular spaces, inflammatory-cell infiltration [1], collagen deposition, and myocardial structural disruption in the MI group [2].
 - 6.3.1. LAB MEDIA: Figure 3C. *Video editor: Compare MI and NC images.*
 - 6.3.2. LAB MEDIA: Figure 3C. *Video editor: Highlight the blue and pink areas in the middle and right-hand side images in the MI panel.*
- 6.4. Quantitative analysis of Masson's trichrome-stained sections demonstrated a significantly greater collagen volume fraction in the MI group than in the control group [1].
 - 6.4.1. LAB MEDIA: Figure 3D. *Video editor: Highlight the red bar labeled "MI" and compare with NC*
- 6.5. Representative M-mode images demonstrated reduced left ventricular contractility in the MI group [1].
 - 6.5.1. LAB MEDIA: Figure 4A. *Video editor: Highlight images labeled "MI" " and compare with NC*
- 6.6. Quantitative analysis revealed a significantly reduced left ventricular ejection fraction [1] and left ventricular fractional shortening in the MI group compared to the control group. [2].
 - 6.6.1. LAB MEDIA: Figure 4B. *Video editor: Highlight the red bar labeled "MI"" and compare with NC*
 - 6.6.2. LAB MEDIA: Figure 4C. *Video editor: Highlight the red bar labeled "MI" and compare with NC*

- 6.7. ELISA (*Elisa*) demonstrated significantly increased serum concentrations of BNP (*B-N-P*) [1], TNF-alpha [2], NF-kappaB p65 (*N-F-Kappa-B-P-Sixty-Five*) [3], and IL-1beta (*I-L-One-Beta*) in the MI group [4].
 - 6.7.1. LAB MEDIA: Figure 4D. *Video editor: Highlight the red bar labeled "MI".*
 - 6.7.2. LAB MEDIA: Figure 4E. *Video editor: Highlight the red bar labeled "MI".*
 - 6.7.3. LAB MEDIA: Figure 4F. *Video editor: Highlight the red bar labeled "MI".*
 - 6.7.4. LAB MEDIA: Figure 4G. *Video editor: Highlight the red bar labeled "MI".*
- 6.8. Three-dimensional fluorescence imaging of tissue-cleared hearts demonstrated the course of the LAD beneath the AIS [1] and showed that ligation at the anatomically defined site produced coronary occlusion [2].
 - 6.8.1. LAB MEDIA: Figure 5A–F.
 - 6.8.2. LAB MEDIA: Figure 5A–F. *Video editor: Highlight E and F*

1. Depilatory
Pronunciation link: <https://www.merriam-webster.com/dictionary/depilatory>
IPA: /dɪˈpɪləˌtɔːri/
Phonetic Spelling: dih·PIL·uh·tor·ee
2. Thoracic
Pronunciation link: <https://www.merriam-webster.com/dictionary/thoracic>
IPA: /θəˈræsɪk/
Phonetic Spelling: tuh·RASS·ik
3. Cefazolin
Pronunciation link: <https://www.merriam-webster.com/medical/cefazolin>
IPA: /sɪˈfæzəlɪn/
Phonetic Spelling: sih·FAZ·uh·lin
4. Intraperitoneal
Pronunciation link: <https://www.merriam-webster.com/dictionary/intraperitoneal>
IPA: /ˌɪntɹəˌperətəˈniːəl/
Phonetic Spelling: in·truh·pair·uh·tuh·NEE·uhl
5. Anesthetized
Pronunciation link: <https://www.merriam-webster.com/dictionary/anesthetize>
IPA: /əˈnesθəˌtaɪzd/
Phonetic Spelling: uh·NES·tuh·tyzed

6. Supine
Pronunciation link: <https://www.merriam-webster.com/dictionary/supine>
IPA: /'suːˌpaɪn/
Phonetic Spelling: SOO·pine
7. Murine
Pronunciation link: <https://www.merriam-webster.com/dictionary/murine>
IPA: /'mjʊrˌaɪn/
Phonetic Spelling: MYUR·ine
8. Tracheal
Pronunciation link: <https://www.merriam-webster.com/dictionary/tracheal>
IPA: /'treɪkiəl/
Phonetic Spelling: TRAY·kee·uhl
9. Intubation
Pronunciation link: <https://www.merriam-webster.com/dictionary/intubation>
IPA: /ˌɪntjuˈbeɪʃən/
Phonetic Spelling: in·tyoo·BAY·shuhn
10. Incisors
Pronunciation link: <https://www.merriam-webster.com/dictionary/incisor>
IPA: /ɪn'saɪzərz/
Phonetic Spelling: in·SY·zerz
11. Pharyngeal
Pronunciation link: <https://www.merriam-webster.com/dictionary/pharyngeal>
IPA: /fə'rɪndʒiəl/
Phonetic Spelling: fuh·RIN·jee·uhl
12. Laryngeal
Pronunciation link: <https://www.merriam-webster.com/dictionary/laryngeal>
IPA: /lə'rɪndʒiəl/, /ˌlærən'dʒiːəl/
Phonetic Spelling: luh·RIN·jee·uhl / lair·uhn·JEE·uhl
13. Glottis
Pronunciation link: <https://www.merriam-webster.com/dictionary/glottis>
IPA: /'glɑːtɪs/
Phonetic Spelling: GLOT·iss
14. Isoflurane
Pronunciation link: <https://www.merriam-webster.com/medical/isoflurane>
IPA: /ˌaɪsoʊ'flɒrˌeɪn/
Phonetic Spelling: eye·soh·FLOOR·ayn
15. Laryngoscope
Pronunciation link: <https://www.merriam-webster.com/dictionary/laryngoscope>
IPA: /lə'rɪŋɡə'skəʊp/
Phonetic Spelling: luh·RING·guh·skohp
16. Dorsum
Pronunciation link: <https://www.merriam-webster.com/dictionary/dorsum>
IPA: /'dɔːrsəm/
Phonetic Spelling: DOR·suhm

17. Epiglottis
 Pronunciation link: <https://www.merriam-webster.com/dictionary/epiglottis>
 IPA: /ˌepəˈɡlɑːtɪs/
 Phonetic Spelling: ep·uh·GLOT·iss
18. Glottic
 Pronunciation link: <https://www.merriam-webster.com/dictionary/glottic>
 IPA: /ˈɡlɑːtɪk/
 Phonetic Spelling: GLOT·ik
19. Catheter
 Pronunciation link: <https://www.merriam-webster.com/dictionary/catheter>
 IPA: /ˈkæθətər/
 Phonetic Spelling: KATH·uh·ter
20. Stylet
 Pronunciation link: <https://www.merriam-webster.com/dictionary/stylet>
 IPA: /ˈstɑɪlət/
 Phonetic Spelling: STY·luht
21. Ventilator
 Pronunciation link: <https://www.merriam-webster.com/dictionary/ventilator>
 IPA: /ˈventəˌleɪtər/
 Phonetic Spelling: VEN·tuh·lay·ter
22. Inspiratory
 Pronunciation link: <https://www.merriam-webster.com/dictionary/inspiratory>
 IPA: /ɪnˈspaɪrəˌtɔːri/
 Phonetic Spelling: in·SPY·ruh·tor·ee
23. Expiratory
 Pronunciation link: <https://www.merriam-webster.com/dictionary/expiratory>
 IPA: /ɪkˈspaɪrəˌtɔːri/
 Phonetic Spelling: ik·SPY·ruh·tor·ee
24. Physiological
 Pronunciation link: <https://www.merriam-webster.com/dictionary/physiological>
 IPA: /ˌfɪziəˈlɑːdʒɪkəl/
 Phonetic Spelling: fiz·ee·uh·LOJ·ih·kuhl
25. Povidone-iodine
 Pronunciation link: <https://www.merriam-webster.com/medical/povidone-iodine>
 IPA: /ˈpoʊvəˌdoʊn ˈaɪəˌdaɪn/
 Phonetic Spelling: POH·vuh·dohn EYE·uh·dyne
26. Ophthalmic
 Pronunciation link: <https://www.merriam-webster.com/dictionary/ophthalmic>
 IPA: /ɑːfˈθælmɪk/
 Phonetic Spelling: off·THAL·mik
27. Sternum
 Pronunciation link: <https://www.merriam-webster.com/dictionary/sternum>
 IPA: /ˈstɜːnəm/
 Phonetic Spelling: STUR·nuhm

28. Pectoralis
Pronunciation link: <https://www.merriam-webster.com/dictionary/pectoralis>
IPA: /ˌpektəˈræləs/
Phonetic Spelling: pek·tuh·RAL·uhs
29. Intercostal
Pronunciation link: <https://www.merriam-webster.com/dictionary/intercostal>
IPA: /ˌɪntərˈkɑːstəl/
Phonetic Spelling: in·ter·KOS·tuhl
30. Cranial
Pronunciation link: <https://www.merriam-webster.com/dictionary/cranial>
IPA: /ˈkreɪniəl/
Phonetic Spelling: KRAY·nee·uhl
31. Thoracotomy
Pronunciation link: <https://www.merriam-webster.com/dictionary/thoracotomy>
IPA: /ˌθɔːrəˈkɑːtəmi/
Phonetic Spelling: thor·uh·KOT·uh·mee
32. Atrial
Pronunciation link: <https://www.merriam-webster.com/dictionary/atrial>
IPA: /ˈɛtriəl/
Phonetic Spelling: AY·tree·uhl
33. Ventricle
Pronunciation link: <https://www.merriam-webster.com/dictionary/ventricle>
IPA: /ˈventrɪkəl/
Phonetic Spelling: VEN·trih·kuhl
34. Pericardium
Pronunciation link: <https://www.merriam-webster.com/dictionary/pericardium>
IPA: /ˌperəˈkɑːrdiəm/
Phonetic Spelling: pair·uh·KAR·dee·uhm
35. Myocardium
Pronunciation link: <https://www.merriam-webster.com/dictionary/myocardium>
IPA: /ˌmaɪəˈkɑːrdiəm/
Phonetic Spelling: my·uh·KAR·dee·uhm
36. Interventricular
Pronunciation link: <https://www.merriam-webster.com/medical/interventricular>
IPA: /ˌɪntərvenˈtrɪkjələr/
Phonetic Spelling: in·ter·ven·TRIK·yuh·ler
37. Sulcus
Pronunciation link: <https://www.merriam-webster.com/dictionary/sulcus>
IPA: /ˈsʌlkəs/
Phonetic Spelling: SUL·kuhs
38. Obliquely
Pronunciation link: <https://www.merriam-webster.com/dictionary/oblique>
IPA: /oʊˈbliːkli/, /əˈbliːkli/
Phonetic Spelling: oh·BLEEK·lee / uh·BLEEK·lee

39. Epicardial
 Pronunciation link: <https://www.merriam-webster.com/medical/epicardial>
 IPA: /,epə'kɑ:rdiəl/
 Phonetic Spelling: ep·uh·KAR·dee·uhl
40. Ligature
 Pronunciation link: <https://www.merriam-webster.com/dictionary/ligature>
 IPA: /'lɪgətʃər/
 Phonetic Spelling: LIG·uh·cher
41. Ischemic
 Pronunciation link: <https://www.merriam-webster.com/dictionary/ischemic>
 IPA: /ɪ'ski:mɪk/
 Phonetic Spelling: ih·SKEE·mik
42. Intrathoracic
 Pronunciation link: <https://www.merriam-webster.com/medical/intrathoracic>
 IPA: /,ɪntrəθə'ræsɪk/
 Phonetic Spelling: in·truh·thuh·RASS·ik
43. Apposition
 Pronunciation link: <https://www.merriam-webster.com/dictionary/apposition>
 IPA: /,æpə'zɪʃən/
 Phonetic Spelling: ap·uh·ZISH·uhn
44. Tachycardia
 Pronunciation link: <https://www.merriam-webster.com/dictionary/tachycardia>
 IPA: /,tækɪ'kɑ:rdiə/
 Phonetic Spelling: tak·ih·KAR·dee·uh
45. Myocardial
 Pronunciation link: <https://www.merriam-webster.com/dictionary/myocardial>
 IPA: /,maɪə'kɑ:rdiəl/
 Phonetic Spelling: my·uh·KAR·dee·uhl
46. Infarction
 Pronunciation link: <https://www.merriam-webster.com/dictionary/infarction>
 IPA: /ɪn'fɑ:rkʃən/
 Phonetic Spelling: in·FARK·shuhn
47. Histopathological
 Pronunciation link: <https://www.merriam-webster.com/dictionary/histopathology>
 IPA: /,hɪstou,pæθə'lɑ:dʒɪkəl/
 Phonetic Spelling: hiss·toh·path·uh·LOJ·ih·kuhl
48. Intercellular
 Pronunciation link: <https://www.merriam-webster.com/dictionary/intercellular>
 IPA: /,ɪntər'seljələr/
 Phonetic Spelling: in·ter·SEL·yuh·ler
49. Masson's trichrome
 Pronunciation link: No confirmed link found
 IPA: /'mæsənz 'traɪ,kroʊm/
 Phonetic Spelling: MASS·uhnz TRY·kroh

50. Contractility

Pronunciation link: <https://www.merriam-webster.com/dictionary/contractility>

IPA: /ˌkɒntrækˈtɪləti/

Phonetic Spelling: kon·trak·TIL·uh·tee

51. Ejection fraction

Pronunciation link: No confirmed link found

IPA: /ɪˈdʒekʃən ˈfrækʃən/

Phonetic Spelling: ih·JEK·shuhn FRAK·shuhn

52. ELISA

Pronunciation link: <https://www.merriam-webster.com/dictionary/ELISA>

IPA: /ɪˈlaɪzə/

Phonetic Spelling: ih·LY·zuh

53. Hyperacute

Pronunciation link: No confirmed link found

IPA: /ˌhaɪpər əˈkjuːt/

Phonetic Spelling: hy·per·uh·KYOOT

54. Fluorescence

Pronunciation link: <https://www.merriam-webster.com/dictionary/fluorescence>

IPA: /flʊˈresəns/

Phonetic Spelling: floor·ESS·uhns