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Title: A Preclinical Model of Orthotopic Heart Transplantation in Bama Miniature Pigs Using Biatrial Technique

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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? **No**

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**

Current Protocol Length
Number of Steps: 25
Number of Shots: 55

Introduction

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

REQUIRED:

1.1. **Jiangping Song:** We aim to establish a clinically relevant pig model of orthotopic heart transplantation to improve preclinical evaluation of cardiac preservation and immunosuppressive strategies.

1.1.1. INTERVIEW: Named Talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B.roll:3.6*

What are the current experimental challenges?

1.2. **Kai Xing:** Pig heart transplantation is technically challenging due to anatomical variability, fragile vascular tissue, and the need for precise anastomosis to avoid postoperative hemodynamic instability.

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

What new scientific questions have your results paved the way for?

1.3. **Jiangping Song:** Our results pave the way for evaluating immunosuppressants, cardiac protection strategies, and xenotransplantation techniques in a clinically relevant large animal model.

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

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 Fuwai Hospital, Chinese Academy of Medical Sciences

Protocol

NOTE: The timestamps were provided by the authors. The postshoot integrator hasn't reviewed the footage.

NOTE: The VO for most of the steps and the onscreen text for some steps have been updated at the postshoot stage based on the shot description provided by the authors.

2. Donor Pig Selection, Surgical Exposure, and Cardioplegia Initiation

Demonstrator: Jiangping Song

2.1. After administering anesthesia, establish carotid artery cannulation **[1-TXT]** and perform urethrostomy **[2]**. Then, disinfect the surgical site with povidone-iodine and drape the area with sterile surgical towels **[3]**.

2.1.1. Talent inserting a cannula into the carotid artery of the anesthetized pig. **TXT: Anesthesia:; Ketamine (10 mg/kg) and Midazolam (1 mg/kg) i.m.** NOTE: "颈部置管.mp4": 15:09-15:32

2.1.2. Talent performing urethrostomy using a scalpel and forceps. NOTE: "消毒.mp4": 0:02-0:12

2.1.3. Talent thoroughly disinfecting the surgical area with povidone-iodine solution and placing sterile surgical drapes around the operative field. NOTE: "铺单.mp4": 01:22-01:35

2.2. To perform thoracotomy, use high-frequency electrocautery to make a midline incision on the anesthetized donor pig from the mid-cervical region to below the xiphoid process **[1]**. Then, perform a sternal incision and cauterize the sternum **[2]**. Use a rib spreader to open the chest cavity and expose the internal organs **[3]**.

2.2.1. Talent making a midline incision from the mid-cervical region to below the xiphoid process. NOTE: "20250412-原位心脏移植.mp4": 0:01-00:20

2.2.2. Talent performing a vertical sternal incision and cauterizing the sternum. NOTE: "20250412-原位心脏移植.mp4": 0:25-00:40

2.2.3. Talent using a rib spreader to open the chest cavity. NOTE: "20250412-原位心脏移植.mp4": 0:50-00:58

2.3. After opening the chest, use electrocautery to lift the thymus gently and separate it from the pericardium to excise it, ensuring no bleeding occurs **[1-TXT]**.

2.3.1. Talent using electrocautery to lift and separate the thymus from surrounding tissues. **TXT: Administer 300 U/kg heparin to achieve systemic anticoagulation and prevent thrombosis** NOTE: 20250412-原位心脏移植.mp4": 01: 05-01:10

2.4. Now, open the pericardium and clear the connective tissue from the anterior side of the main pulmonary artery **[1]**.

2.4.1. Talent making a pericardial incision and clearing the connective tissue from the anterior side of the main pulmonary artery. NOTE: 20250412-原位心脏移植.mp4": 01: 12-01:30

2.5. Use a 5-0 *(five-oh)* Prolene suture to place a purse-string suture on the adventitia of the proximal ascending aorta and secure it with a tourniquet **[1]**. Then insert the cardioplegia cannula into the aorta and secure it using the same suture **[2]**.

2.5.1. Talent placing a purse-string suture around the proximal ascending aorta, securing with a tourniquet. NOTE: "20250412-原位心脏移植.mp4": 12: 30-13:10

2.5.2. Talent inserting the cardioplegia cannula and tightening the suture. NOTE: "20250412-原位心脏移植.mp4": 13: 50-14:18

2.6. Initiate perfusion with cardioplegic solution **[1-TXT]** while simultaneously irrigating the cardiac surface with ice-cold saline for myocardial protection **[2]**.

2.6.1. Initiate cardioplegic perfusion. **TXT: 500ml modified St. Thomas solution and 500ml UW solution; Maintain perfusion pressure at 80 - 100 mmHg** NOTE: "20250412-原位心脏移植.mp4": 14: 15-14:20

2.6.2. Irrigate with ice-cold saline for myocardial protection. NOTE: "20250412-原位心脏移植.mp4": 14: 22-14:28

2.7. Obtain the donor heart **[1].**

2.7.1. Obtain the donor heart. NOTE: "20250412-原位心脏移植.mp4": 18: 30-14:40, 21:18-21:22

3. Recipient Heart Excision, Implantation, and Functional Restoration

3.1. For cystostomy, incise the bladder wall, insert a urinary catheter, and secure it in place **[1-TXT]**.

3.1.1. Talent incising the bladder wall, inserting a urinary catheter, and securing it. **TXT: Perform anesthesia, disinfection, and draping following the same procedure**

used for the donor NOTE: “膀胱造瘘.mp4”: 00:00-01:00

3.2. To begin implantation, after performing cardiac incision, place the donor heart in the recipient’s mediastinum **[1-TXT].**

3.2.1. Talent placing the donor heart in the recipient’s mediastinum. **TXT: Perform thoracotomy, anatomical dissection, and cardioplegic arrest before incision** NOTE: “20250412-原位心脏移植.mp4”: 29:14-21:35

3.3. Begin with left atrial anastomosis using the double-needle sliding suture technique to anastomose down to the mid-lower part of the atrial septum **[1].** On the other side, suture along the top of the left atrium, down to the septum **[2]**.

3.3.1. Talent using double-needle sliding to anastomose down to the mid-lower part of the atrial septum. NOTE: “20250412-原位心脏移植.mp4”: 31:35-32:05

3.3.2. Shot of the top of the left atria down to the septum being sutured. NOTE: “20250412-原位心脏移植.mp4”: 32:45-32:55

3.4. Constantly assess the size difference between the donor and recipient's left atrium and fold any excess tissue appropriately to complete the anastomosis **[1]**. After de-airing the left atrium, tie the suture ends tightly **[2]**.

3.4.1. Talent assessing the size difference between the donor and recipient left atrium and folding excess tissue. NOTE: “20250412-原位心脏移植.mp4”: 34:00-35:00

3.4.2. Talent completing the circumferential suture and finally tying the knot. NOTE: “20250412-原位心脏移植.mp4”: 38:00-38:45、46:05-46:37

3.5. Adjust the donor heart to near-normal position and begin right atrial anastomosis from the lower end of the right atrial septum **[1]**. Pass one suture line upwards counterclockwise **[2-TXT].** Ensure the other line goes downwards along the right atrial wall **[3].** Finish the anastomosis by tying the two suture lines together at the midpoint of the right atrium’s lateral wall, securing the suture **[4]**.

3.5.1. Talent aligning and beginning suture from right atrial septum. NOTE: “20250412-原位心脏移植.mp4”: 48:38-49:10

3.5.2. Shot of 1 suture line going upwards in anti-clockwise direction. NOTE: “20250412-原位心脏移植.mp4”: 49:21-50:16

3.5.3. Shot of the other suture line going downwards. NOTE: “20250412-原位心脏移植.mp4”: 01:00:41-01:01:32

3.5.4. Talent completing the circumferential suture and finally tying the knot. NOTE: “20250412-原位心脏移植.mp4”: 01:03:11-01:04:07

3.6. For aorta anastomosis, perform end-to-end anastomosis using the sliding technique, starting from the posterior wall of the vessel **[1]** and continuing suturing along the anterior wall of the aorta **[2]**. Finally, tie the suture tightly to the front wall **[3]**. Use the same technique for pulmonary artery anastomosis after rewarming the recipient **[4].**

3.6.1. Talent starting aortic anastomosis from the posterior wall of the vessel. NOTE: "20250412-原位心脏移植.mp4": 01:04:50 -01:05:10

3.6.2. Talent suturing anterior wall of the aorta. NOTE: "20250412-原位心脏移植.mp4": 01:07:14 -01:07:57

3.6.3. Shot of the suture being tied at the front wall. NOTE: "20250412-原位心脏移植.mp4": 01:08:20-01:08:48

3.6.4. Use same technique for pulmonary artery anastomosis after rewarming recipient. NOTE: "20250412-原位心脏移植.mp4": 01:10:30-01:11:00

3.7. After completing the pulmonary artery anastomosis, insert an air venting needle into the root of the ascending aorta **[1]**. Remove the aortic cross-clamp to allow heart resuscitation **[2-TXT]**.

3.7.1. Talent inserting air venting needle into the root of the ascending aorta. NOTE: "20250412-原位心脏移植.mp4": 01:17:03-01:17:55

3.7.2. Talent removing cross-clamp. **TXT: Let an anesthetist assist with lung inflation** NOTE: "20250412-原位心脏移植.mp4": 01:18:01-01:18:30

3.8. Defibrillation restores cardiac rhythm **[1]**. When the heart restarts, support initial cardiac function using extracorporeal circulation **[2-TXT]**.

3.8.1. Defibrillation restores cardiac rhythm. NOTE: "20250412-原位心脏移植.mp4": 01:19:17-01:19:83

3.8.2. Support initial cardiac function using extracorporeal circulation **TXT: Check all anastomoses for bleeding and ensure hemostasis** NOTE: "20250412-原位心脏移植.mp4": 01:38:57-01:39:20

3.9. Place a temporary epicardial pacemaker wire on the right atrium and right ventricle surface. Then place drainage tubes in the mediastinum and thoracic cavity **[1].** Finally, discontinue extracorporeal circulation and close the cannulation sites **[2].**

3.9.1. Talent placing a temporary epicardial pacemaker wire on the right atrium and right ventricle surface and placing drainage tubes. NOTE: "20250412-原位心脏移植.mp4": 01:50:28-01:51:10

3.9.2. Discontinue extracorporeal circulation and close the cannulation sites. NOTE: “20250412-原位心脏移植.mp4”: 02:27:25-02:28:30

3.10. Check for bleeding points **[1]** and place the drainage tubes **[2]**. Finally, close the midline incision using standard techniques **[3].**

3.10.1. Check for bleeding points. NOTE: “20250412-原位心脏移植.mp4”: 02:29:13-02:29:35

3.10.2. Place drainage tubes. NOTE: “20250412-原位心脏移植.mp4”: 02:42:13-02:42:36

3.10.3. Close the midline incision using standard techniques. NOTE: “20250412-原位心脏移植.mp4”: 02:52:30-02:52:55, “20250412-原位心脏移植.mp4”: 02:55:30-02:55:50, “20250412-原位心脏移植.mp4”: 03:07:28-03:07:56

NOTE: The authors mentioned there is a final frame: “20250412-原位心脏移植.mp4”: 03:12:20 but did not provide any details about this shot.

Results

4. Results

4.1. Central venous pressure was significantly higher in the bicaval group than in the biatrial group at 12 hours post-operation **[1]**, and this difference remained highly significant at 48 hours post-operation **[2]**.

4.1.1. LAB MEDIA: Figure 2E. *Video editor: Show the left graph labeled "12h post-op", highlighting the higher cluster of circular data points under "Bi-caval" and the lower square data points under "Bi-atrial".*

4.1.2. LAB MEDIA: Figure 2F. *Video editor: Show the right graph labeled "48h post-op", again highlighting the distinct vertical separation between the elevated "Bi-caval" data points and the lower "Bi-atrial" data points.*

4.2. ICU monitor readings showed that at 12 hours post-operation, the bicaval group had a central venous pressure of 24.2 millimeters of mercury **[1]**, whereas the biatrial group showed a markedly lower value of 10.6 millimeters of mercury **[2]**.

4.2.1. LAB MEDIA: Figure 2A. *Video editor: Focus on the blue CVP value "24.2" in the middle-right portion of the monitor screen labeled "Bi-caval 12h post-op".*

4.2.2. LAB MEDIA: Figure 2C. *Video editor: Focus on the blue CVP value "10.6" on the screen labeled "Bi-atrial 12h post-op".*

4.3. At 48 hours post-operation, the bicaval group continued to show elevated central venous pressure at 30.3 millimeters of mercury **[1]**, in contrast to the biatrial group which maintained a lower value of 11.8 millimeters of mercury **[2]**.

4.3.1. LAB MEDIA: Figure 2B. *Video editor: Highlight the blue CVP value "30.3" on the monitor labeled "Bi-caval 48h post-op".*

4.3.2. LAB MEDIA: Figure 2D. *Video editor: Highlight the blue CVP value "11.8" on the monitor labeled "Bi-atrial 48h post-op".*

4.4. Arterial blood gas analysis during cardiopulmonary bypass revealed a rise in pH to 7.699 **[1]** and a drop in carbon dioxide partial pressure to 22.2 millimeters of mercury **[2]**.

4.4.1. LAB MEDIA: Table 1. *Video editor: Zoom in on the "pH" row to show the increase from "Baseline" to "CPB" (from 7.475 to 7.699).*

4.4.2. LAB MEDIA: Table 1. *Video editor: Highlight the "PCO_2" row where the value drops from 37.8 to 22.2 millimeters of mercury from "Baseline" to "CPB".*

4.5. After heart resuscitation, arterial oxygen partial pressure peaked at 425 millimeters of mercury **[1]**.

4.5.1. LAB MEDIA: Table 1. *Video editor: Highlight the "PO_2" row and focus on the spike to "425" under the "Heart resuscitation" column.*

Pronunciation Guides:

1. Carotid Artery
- **Pronunciation Link:** https://www.merriam-webster.com/dictionary/carotid%20artery
- **IPA:** /kəˈrɑːˌtɪd ˈɑːr.tər.i/
- **Phonetic Spelling:** kuh-rah-tid ar-tuh-ree

2. Urethrostomy
- **Pronunciation Link:** https://www.merriam-webster.com/medical/urethrostomy
- **IPA:** /jʊˌriːˈθrɒstəmi/
- **Phonetic Spelling:** yoo-ree-thros-tuh-mee

3. Povidone-Iodine
- **Pronunciation Link:** https://www.merriam-webster.com/medical/povidone-iodine
- **IPA:** /ˈpoʊ.vɪ.doʊn ˈaɪ.əˌdaɪn/
- **Phonetic Spelling:** poh-vi-dohn eye-uh-dine

4. Thoracotomy
- **Pronunciation Link:** https://www.merriam-webster.com/dictionary/thoracotomy
- **IPA:** /ˌθɔːrəˈkɒtəmi/
- **Phonetic Spelling:** thaw-ruh-kot-uh-mee

5. Electrocautery
- **Pronunciation Link:** https://www.merriam-webster.com/dictionary/electrocautery
- **IPA:** /ɪˌlɛk.trəˈkɔː.tər.i/
- **Phonetic Spelling:** ih-lek-troh-kaw-tuh-ree

6. Xiphoid Process
- **Pronunciation Link:** https://www.merriam-webster.com/dictionary/xiphoid%20process
- **IPA:** /ˈzaɪ.fɔɪd ˈprɑː.ses/
- **Phonetic Spelling:** zai-foid prah-ses

7. Sternum
- **Pronunciation Link:** https://www.merriam-webster.com/dictionary/sternum
- **IPA:** /ˈstɜːr.nəm/
- **Phonetic Spelling:** stur-nuhm

8. Pericardium
- **Pronunciation Link:** https://www.merriam-webster.com/dictionary/pericardium
- **IPA:** /ˌpɛr.ɪˈkɑːr.di.əm/
- **Phonetic Spelling:** peh-ri-kar-dee-uhm