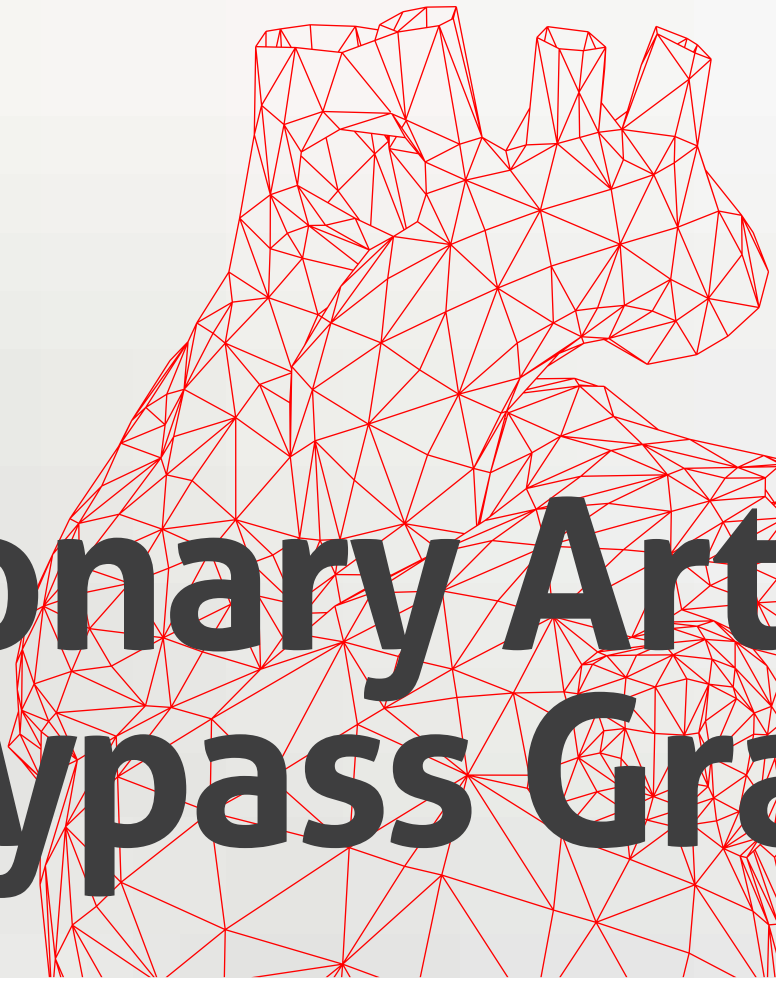

Case Study: Coronary Artery Bypass Graft

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Coronary artery disease is a serious and life-threatening disease. This paper will discuss a case of a 76-year- old undergoing a Coronary Artery Bypass Graft procedure. This brief includes patient parameters, pathophysiology, cardiac physiology, anesthesia's role, and cardiac bypass. The patient was in the operating room at 07:00 with anesthesia induction beginning at 07:52 and completed by 08:25. The procedure ended at 16:31 without incident, and the patient was transferred to the ICU at 16:45.

Patient Parameters

A 76-year-old female was presented to the operating room for a cardiopulmonary bypass graft. The patient's admitting weight was 63.5 kilograms with a registered height of 62.0 inches and was designated by the Anesthesia care team as an ASA IV. The patient is allergic to morphine, which is a common anesthetic medication used preoperatively for patients needing a CABG (Jannati, 2019). Prior surgical history includes multiple PCI's that have since become stenotic and a hysterectomy. The patient's medical history includes multiple concomitant pathologies, including hypotension, unstable coronary artery disease, IBS- C, renal failure resulting from acute kidney injury; type AKI, Cr 1.3, hypothyroidism, and rheumatoid arthritis. Due to the patient's medical history, it is important to note medications taken the day of surgery and PRN, which are: Temazepam PRN (30 mg), Tofacitinib BID (5mg), levothyroxine 50 mcg, prasugrel (10mg), Atrovastin (40mg) Imdur (120 mg), lisinopril (10 mg), nitroglycerin 0.3 PRN, Aspirin (.81 mg), Metoprolol succinate (25 mg).

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Cardiac physiology

The coronary arteries are arguably one of the most important anatomical structures in the circulatory system. Mechanically for the body to function, the heart must supply oxygen-rich hemoglobin to itself before the rest of the body, which is accomplished via the location of the coronary arteries emerging from the aortic sinus just superior to the aortic leaflets. Given the importance of the coronary arteries and increasing incidences of coronary artery disease, the anesthesia technologist needs to have a functional understanding of coronary artery disease. *Morgan and Mikhail's Clinical Anesthesiology* 6th Edition (2018) states "*the overall incidence of CAD in surgical patients is estimated between 5% and 10%* (Butterworth, 2018, p. 395)." There are two types of coronary artery disease. The first is arteriosclerosis, whose etiology is the result of natural aging. The coronary arteries become fibrotic and narrowed, increasing the resistance to eject blood through the vessels. Atherosclerosis, the most common form of coronary artery disease, is the result of plaque buildup inside the arteries due to a high cholesterol diet. Risk factors for CAD include hyperlipidemia, hypertension, diabetes, cigarette smoking, and increasing age. (Butterworth, 2018, p. 395). Plaque buildup in the coronary arteries, if left untreated, can result in morbidity and mortality. The disease process for atherosclerosis begins with plaque formation on the arterial walls, increasing the resistance necessary to eject oxygen-rich blood to the myocardium. It is important to note that the pathological issues surrounding myocardial perfusion do not stop with coronary artery disease. Plaque buildup can lead to a complete blockage causing clot formation, leading to a myocardial infarction (MI), which can be described as tissue death to a specific area of the heart (libretexts, 2020).

A coronary artery bypass graft is used to treat coronary artery disease. This procedure involves the removal of another vessel from the circulatory system to bypass the damaged vessel. Common vessels used include great saphenous veins, internal mammary arteries, and radial arteries (NHS). The procedure relies on the surgical team forming an anastomosis around the diseased area. The anastomosis can be done surgically or naturally via the body redirecting blood flow around the blockage to prevent ischemia and to maintain homeostasis.

Cardiac Physiology Relating to Cardiac Bypass

The bypass machine is an essential piece of equipment in the cardiac room as it replaces the circulatory and perfusion responsibilities of the heart while the surgical team corrects the damaged vessels. By replacing the mechanical and perfusion workload of the heart, the bypass machine allows for motionless access to the heart during surgical intervention. The mechanism of action for the bypass works via cardioplegia that is "*delivered either antegrade into the aortic root or retrograde into the coronary sinus or both* (Sarkar, 2019). The two connection sites link the heart to the machine; the right atrium, where deoxygenated blood enters the heart, and the aorta responsible for ejection and perfusion. The connection site in the right atrium allows the machine to take the deoxygenated blood from the atrium pumping it into an oxygenator reservoir outside of the body (*A Heart Surgery Overview*, 2020). Under normal physiological conditions, deoxygenated blood enters the right atrium from the superior and inferior vena cava. This blood is ejected from the right ventricle into the pulmonary system through the pulmonary arteries.

"The two connection sites link the heart to the machine; the right atrium, where deoxygenated blood enters the heart, and the aorta responsible for ejection and perfusion."

Blood flow throughout the entire body relies on millions of vascular capillary beds. it is at the vascular capillary beds are where oxygen enters the tissue. This is referred to as capillary action, where oxygen-poor blood can shift superiorly without the reliance on gravity. Once oxygen transfer is complete, the venous system moves the deoxygenated blood sending it back to the right atrium through the IVC or SVC. Eventually, it is sent to the lungs, where that same oxygen-poor blood is now re-oxygenated. Thus, completing the pulmonary system. (Libretexts, 2020)

This oxygen-rich blood is then sent out of the lungs and into the left atrium through the pulmonary veins (these are the only veins that carry oxygenated blood). It goes through the bicuspid valve into the left ventricle and into the left ventricle, feeding the coronary arteries. This is where the "heart feeds itself first" concept comes into play, sending blood through

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the coronary arteries to oxygenate the myocardium. The rest of the oxygen-rich blood is sent out to the tissues and organs, completing the systemic system.

With the groundwork laid for understanding the circulatory system established, the importance of the bypass machine can be fully grasped. As stated above, there are two connection sites in the heart, one at the right atrium, and the other at the aorta

"The aorta is done first after heparinization because of the hemodynamic problems associated with venous canulation and to allow convenient and rapid transfusion from the pump oxygenator"

~ Butterworth, 2018 ~

The right atrium connection port takes the blood out of the right atrium and replaces the function of the lungs through external blood oxygenation. This oxygenated blood is sent to the connection port on the aorta, where it can be pumped to the rest of the body. Because of the change in how the blood is moved into the bypass machine, the development of coagulopathy is possible. Due to the increased chance of coagulopathy, the blood must be treated with an anticoagulant. Heparin is the primary anticoagulant used for this procedure. Heparin works by enhancing the inactivation rate of antithrombin III reversing the activated clotting factors, essentially halting the binding of factor X and prothrombin (Ofosu et al., 1982). According to Butterworth (2018), "*...the accuracy of anticoagulation agent is confirmed by measuring ACT, a longer ACT time of 400-480 s is accurate*" (Butterworth, 2018, p. 462). For this procedure, the patient was given 25,000 units of Heparin to initiate the antithrombic state. Once the patient was off-bypass, the anesthesia team, in coordination with the perfusionist, administered 250mg of protamine. Protamine is the primary reversal agent of Heparin and is used to restore hemostasis after high-dose heparin administration.

Anesthesia Induction and Maintenance

Induction for the patient was uneventful, using propofol, fentanyl, and rocuronium. It is important to note that typical induction of anesthesia for cardiovascular surgery relies on etomidate, as propofol acts as a cardiovascular depressant lowering blood pressure. Based on the preoperative evaluation, the provider decided that the patient could withstand the effects of propofol. Before the case started, the ACT prepared a Macintosh 3 blade and a 7.5mm endotracheal tube. As members of the Anesthesia Care Team, the certified anesthesia technologist must verify the laryngoscope light is functioning and that brightness is adequate. Additionally, it is essential to check the ETT cuff and ensure it maintains pressure. The airway evaluations were uneventful, indicating a standard direct laryngoscopy with no need for airway manipulation or the initiation of the ASA difficult airway algorithm.

For the duration of the procedure, PCV-VG was utilized until bypass started at 11:30; at the conclusion of bypass, the ventilation mode returned to PCV-VG. Once the patient is removed from cardiopulmonary bypass, it is important to take precautionary lung-protective management techniques to preserve pulmonary function in the postoperative area. For this procedure, the anesthesia care team utilizes continuous positive airway pressure (CPAP) to protect pulmonary function. Additionally, it is acceptable to utilize low tidal volumes to preserve pulmonary function (Echeverria-Villalobos, 2019). General anesthesia was maintained using a 1.2% delivery of Isoflurane with the mechanical ventilator being set on a 1:2 I:E ratio. PEEP levels were set to 7cm/H2O with a respiration rate of 13.

Patient Monitors

Prior to induction, all ASA monitors were placed, ECG, SpO2, noninvasive blood pressure monitoring, temperature monitoring. Additionally, the anesthesia care team placed an arterial line, central line catheter, Swan-Ganz catheter, and utilized a transesophageal echocardiogram. *The Anesthesiologist's Manual of Surgical Procedures* (2019) confirms the importance of having all standard monitors and the addition of an arterial line, CVP, and PA catheter (Jaffe, 2019, p. 358). For cardiovascular surgeries, the strategic placement of monitors is essential so that accurate data can be collected without violating the integrity of the surgical area. ECG pads should be placed along the midaxillary line and on the scapula. Furthermore, due to the placement of these monitors away from the chest, it is necessary to place Tegaderms or some other form of adhesive over the ECG pads to maintain adequate skin contact. The only major complication regarding hemodynamic monitoring concerned the placement of the arterial line. The procedure required four radial artery punctures with successful cannulation

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occurring after utilization of a linear ultrasound probe. The primary complication regarding arterial cannulation was the development of hematomas.

Anesthesia Care Team's Role

The ACTs' role during bypass encompasses several vital tasks. First, a timed sequence for ABGs which were administered every 30-minutes. Two, temperature management and monitoring were accomplished via an underbody cardiac warmer. Three, urine monitoring is done more regularly; to ensure renal function is not impaired from the CPB. During this procedure, we noted a total urine output of 1000mL; this volume was replaced with 1000mL of 0.9% NaCl crystalloid solution.

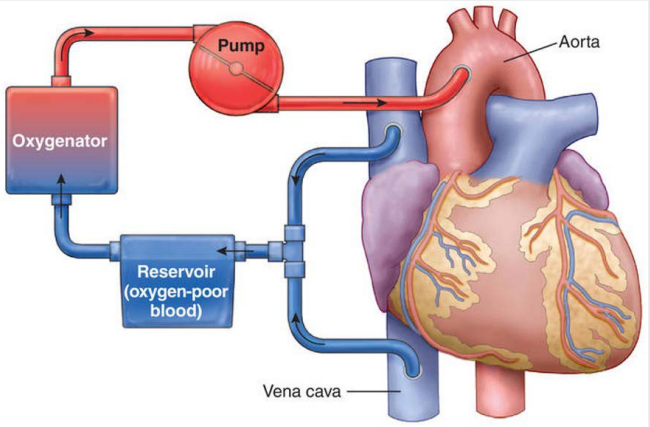
During bypass, medication delivery is reduced and primarily administered through the bypass; however, *Morgan and Mikhail's Clinical Anesthesiology* (2018) make an important statement "*failure to give anesthetic agents, may result in awareness and recall...small amounts of volatile anesthetics are given via the oxygenator*". Additionally, Butterworth (2018) indicates administering multiple pharmacological agents through the CBP to prevent awareness such as, benzodiazepines, propofol, opioids, or ketamine (Butterworth, 2018, p. 467).

Arterial Blood Gas Results.

Arterial blood gas samples were taken periodically throughout the case. Blood gases are essential during a cardiovascular procedure as they indicate the patient's pH, hemoglobin, and potassium levels, among other valuable information. The first blood gas was done at 08:30 results are as follows: pH of 7.34, pCO2 of 49, pO2 of 499, BEecf of 1, HCO3 27, % sat 100, Na 139, K 4, Calcium ionized 1.2, Glucose 111, Hct 27and Hgb 9.2, indicating a relatively normal patient status. During the procedure, the third arterial blood gas indicated lower hemoglobin levels. To compensate for the drop, the ACT administered one unit of pRBC, which under normal circumstances will yield a 1g/dL increase in hemoglobin.

Conclusion

Emergence of the patient was uneventful with the care team transporting the patient to the ICU for recovery. Coronary artery disease is a complex and dangerous disease that can result in a myocardial infarction. For this procedure, a positive outcome was attained from proper anesthetic monitoring via the use of complex hemodynamic monitors, vigilance during monitoring and the success communication of all members of the anesthesia care team and surgical team.



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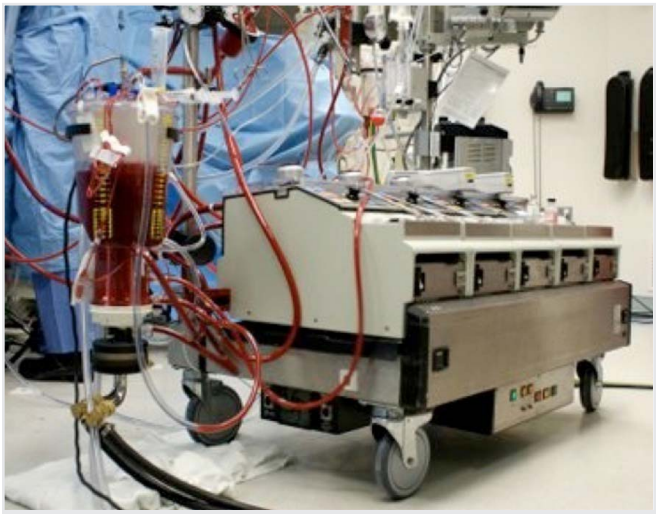

Citation: Ehrahn, (May 7, 2015) Wikipedia.org

Value	Arterial blood	Mixed venous
pH	7.40 (7.35-7.45)	7.36 (7.31-7.41)
paO_2	80-100 mmHg	35-40 mmHg
O_2 saturation	95%	70-75%
$PaCO_2$	35-45 mmHg	41-51 mmHg
HCO^{3-}	22-26 $mEqL^{-1}$	22-26 $mEqL^{-1}$
BE	−2 to +2	−2 to +2

(Table adapted from[3]); O_2: Oxygen, paO_2: Partial pressure of oxygen in arterial blood, pH: Acidity/alkalinity, $PaCO_2$: Partial pressure of oxygen in arterial blood, HCO^{3-}: Bicarbonate in blood, BE: Base excess

Blood gas analysis for bedside diagnosis - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Arterial-versus-venous-blood-gas_tbl1_261069986 *[accessed 29 Jul, 2021]*

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Continuing Education Quiz

To test your knowledge on this issue's article, provide correct answers to the following questions on the form below. Follow the instructions carefully.

1. The administration of one unit of pRBC will result in an 1g/dL increase of hemoglobin under normal circumstances.
a. True
b. False

2. What medication is commonly given during the induction of most cardiovascular surgeries?
a. Etomidate
b. Propofol
c. Potassium
d. Nitroprusside

3. Heparin works in combination with _____ to prevent clotting.
a. Antithrombin III
b. Factor X
c. Von Willebrand Factor
d. Protamine

4. What medication reverses the effects of Heparin?
a. Nitroglycerin
b. Flumazenil
c. Protamine
d. Antithrombin III

5. ECG pads should be placed around the midaxillary line and scapulae during cardiovascular surgery.
a. True
b. False

6. _____ can be used to protect the lungs and preserve pulmonary function during bypass surgery.
a. CPAP
b. Propofol
c. Etomidate
d. DPAP

7. CAD occurs in approximately _____ of the population.
a. 20-30%
b. 5-10%
c. 5-15%
d. 15-20%

8. Arteriosclerosis is associated with the natural aging process.
a. True
b. False

9. The _____ vessel the surgical team may harvest for a CABG.
a. Internal mammary artery
b. Femoral artery
c. Radial vein
d. External rotary vein

10. SpO2 is not considered a standard ASA monitor.
a. True
b. False

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1:	A B	**6:**	A B C D
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3:	A B C D	**8:**	A B
4:	A B C D	**9:**	A B C D
5:	A B	**10:**	A B

Quiz 2 of 2

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