Anesthesia for Transcatheter Aortic Valve Implantation

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Transcatheter aortic valve implantation (TAVI) represents a unique challenge for anesthesiologists in the Cardiac Catheterization Laboratory (CCL).

A clear understanding of the pathophysiology together with the clinical implications of the diagnostic and therapeutic intervention of aortic valve disease is mandatory.
At present, patients undergoing TAVI are at a more advanced age and have more comorbidities than patients scheduled for conventional aortic valve replacement.

The key for successful outcomes entails careful preoperative assessment, appropriate intraoperative monitoring and imaging, meticulous management of hemodynamics, and early treatment of expected side effects and complications.
Transcatheter aortic valve implantation (TAVI)

TAVI has been reported to be safe and effective for inoperable patients with severe aortic stenosis (AS), there can be serious risks associated with the procedure:

- Death.
- Hypothermia.
- Aspiration of gastric contents.
- Hypovolemia.
- Hemorrhage.
- Severe hemodynamic instability.
- Various procedure-related complications (e.g., retroperitoneal bleeding, ventricular perforation, and aortic root rupture).
The Cardiac Cath Lab: provides unique challenges to the anesthesiologist: limited working area, lighting and temperature inadequacies (computerized radiology equipment requires a low temperature and the rooms are usually cooler than commonly set at the OR.

The anesthesia care team should adopt special skills and attitudes:

1. Advisable to have experience with cardiothoracic anesthesia
2. Knowledge of echocardiography and fluoroscopy
3. Participate regularly in the Interventional Cardiology program
A hybrid room: would be the ideal environment to perform TAVI procedures as it combines the advantages of both locations (CCL and OR).

In addition, factors like communication, good planning and preparation, availability of adjacent services as Cardiothoracic Surgery and Anesthesia, Vascular Surgery, Intensive Care, Diagnostic Laboratory, and even ancillary personnel are all of crucial importance. In this scenario, the anesthesiologist plays the role of a quality enforcer before, during, and after the intervention.
The ultimate goal of the preoperative risk evaluation is to optimize the medical condition of the patient and thereby reduce morbidity and mortality associated with TAVI.

It is best conducted by a team of physicians: a cardiologist, anesthesiologist, and a cardiothoracic surgeon:

- All previous surgical and interventional procedures should be well documented at admission.
- Signs of congestive heart failure.
- Intercurrent diseases should be identified.
The standard of care in the CCL should equal that of the OR.

Once a decision to perform TAVI has been made, the patient is typically admitted to the hospital one day before the intervention. Laboratory evaluations should be performed.

Because anesthetic management needs to be tailored for individual patients, the anesthesiologist can now plan for the procedure along with the interventional cardiologist.
Transfemoral versus Transapical Approach

- **Transfemoral approach** need adequate ilio-femoral vessel sizes (femoral and iliac arteries ≥ 7mm and minimal ilio–femoral calcification and tortuosity).

- Patients with severe peripheral vascular disease and short vessel segments with lesser diameter (iliac–femoral arteries < 7mm) need an alternative approach to the transfemoral route.

- **Transapical approach** can be pursued depending on operator experience and device availability.
THV PATIENT EVALUATION

PRE-PROCEDURAL PATIENT ASSESSMENT
TRANSFEMORAL VERSUS TRANSAPICAL APPROACH PATIENT SELECTION

OUTLINE
- Minimum Patient Selection Requirements for Transapical and Transfemoral Procedures
  I. Risk Assessments
  II. Indications
  III. Morphology Factors
- Patient Selection Guidelines for Transapical versus Transfemoral Approach
- Cardiac Considerations

Patients may be eligible for either delivery approach. Both, surgeon and cardiologist make a joint decision to determine appropriate transcatheter access procedure.
Preoperative Diagnostics of the severity of AS and adequacy of the iliac-femoral vasculature can be thoroughly studied with:

- **Echocardiography (TTE, TEE).**
- **Angiography.**
  1. Coronary Angiogram.
  2. Aortogram.
  3. Aorto-iliac Angiogram.
- **Multislice computed tomography (CT).**
- **Magnetic resonance imaging (MRI).**
PREOPERATIVE DIAGNOSTICS

ECHOCARDIOGRAPHY: TEE ASSESSMENTS

- TEE not required in all patients
  - If annulus appears too small, large or can not be visualized by TTE, TEE is recommended for assessment of annulus size.
- TEE aortic annulus sizing typically measures greater than TTE by ~1 mm
- Recommended at time of implantation for final determination of bioprosthesis size

THV SIZING RECOMMENDATIONS

- 18-22mm Annulus → 23mm Valve
- 21-25mm Annulus → 26mm Valve

Sizing Considerations: 1) Patient Size
2) Degree of root and aortic calcification
PREOPERATIVE DIAGNOSTICS
ECHOCARDIOGRAPHY: TEE ASSESSMENTS

- May discover vegetation, thrombus, bulky calcium etc... that may exclude the patient
THV PATIENT EVALUATION

PREOPERATIVE DIAGNOSTICS

ANGIOGRAPHY

- Coronary Angiogram
- Aortogram
- Aorto-Iliac Angiogram
THV PATIENT EVALUATION

PREOPERATIVE DIAGNOSTICS
ANGIOGRAPHY: AORTOGRAM

BULKY CALCIFICATION OF AORTIC VALVE

- Locate coronary ostia relative to valve leaflets
  
  "Will bulky leaflets compromise left main artery?"

- THIS PATIENT SHOULD BE EXCLUDED!

CONSIDERATION

Stenting a bulky aortic valve can result in displacing a calcific nodule and a possible occlusion of the left coronary ostium.
THV PATIENT EVALUATION

PREOPERATIVE DIAGNOSTICS

ANGIOGRAPHY: AORTO-ILIAC ANGIOGRAM

- Assess ilio-femoral arterial access
- Short vessel segments with lesser diameter (7mm for 22F and 8mm for 24F) may be acceptable
- Vascular entry recommended at middle of femoral head, therefore, visualization of femoral artery at same level becomes important

Assess vessel measurements of bioprosthesis pathway (including aorta size)

10.66 mm

8.42 mm

8.18 mm

RECOMMENDATION
Pigtail placement should be below renal arteries. Higher placement may cause inadequate visualization where as too low of placement may cause aorta-iliac bifurcation disease to be missed.
THV PATIENT EVALUATION

PREOPERATIVE DIAGNOSTICS

ADDITIONAL ASSESSMENTS : CT

- In addition to aorto-iliac angiograms, CT’s assist in evaluating vascular access
- CT’s essential in patient’s with borderline vessel sizes
THV PATIENT EVALUATION

PREOPERATIVE DIAGNOSTICS

ADDITIONAL ASSESSMENTS: MRA

- MRA may also be used to assess aortic annulus size
PREOPERATIVE DIAGNOSTICS

ADDITIONAL ASSESSMENTS: CT

- If using CT to evaluate valve sizing, use axis perpendicular to valve
  - Not as reliable as originally thought to assess size of valve
  - Can differ from echocardiography by as much as 3mm

Comparison of a Valve Size Estimates Using Different Imaging Modalities

CT's may yield larger valve size estimates when compared with a TEE, and likewise TEE estimations are typically larger when compared with TTE.
Global Perspective of Patient Preparation and Setup for TAVI

- All patients receive antibiotic prophylaxis (first-generation cephalosporin or vancomycin) 1 hour before the procedure.

- Before the inflation of the balloon to dilate aortic valve Heparin 150-300 unit/kg should be given to have ACT $\geq$ 250

- Peri-interventional goals consist of:
  1. Maintenance of sinus rhythm (50–60 beats/min, higher rates with coexisting aortic insufficiency).
  3. Avoiding systemic hypotension with adrenergic agonists.
Patients with severe AS usually have limited coronary flow and/or cardiovascular reserve that can negatively influence cerebral and pulmonary blood flow.

Furthermore, coronary artery disease can be identified in approximately 50% of patients undergoing TAVI and can increase the complexity of the procedure. In approximately 10% of the patients PCI is performed during the index procedure but before valve implantation.

Occasionally, a percutaneous ventricular assist device (pVAD) can facilitate the procedure especially for patients with LV dysfunction.
SETUP, EQUIPMENT, AND PREPARATION IN THE CCL FOR TAVI

- Appropriate protection from Radiation for both the patient and personnel in the CCL, including thyroid shields.

- Before starting the procedure, the anesthesia care team should ensure that all of the following items are present and are functioning correctly:
  1. Oxygen and suction equipment reach the patient. A scavenging system should be available.
  2. Anesthesia workstation, emergency cart, and supplies equivalent to the OR setup.
  3. Immediate availability of a defibrillator and self-inflating (Ambu) resuscitation bag.
  4. Extensions both for the respiratory circuit and for IV lines. All equipment should be properly positioned in the CCL.
  5. Standard and invasive monitors.
  6. Adequate padding for patient comfort to prevent any tissue damage.
  7. A patient heating device to avoid hypothermia.
The choice of the anesthetic technique varies among centers and is probably not associated with a significant difference in outcome, but a common feature to all of the techniques is that they challenge the cardiovascular system. This fact together with greater potential for complications, make general anesthesia for TAVI, in our opinion, a first choice.

GA can provide physiological stability and can improve the tolerability of the procedure. Immobility of the patient may facilitate the delivery and deployment of the prosthesis and may allow for better control of complications should they occur.

In patients currently undergoing TAVI, anesthetic requirement are typically reduced because of advanced age and decreased cardiac output.
When patients arrive in the CCL, basic anesthetic monitoring is established and insertion of:

1. **Peripheral venous access** (Large-bore)
2. **Arterial line** (Right radial/brachial).
3. **Central-line** placement in the right internal jugular vein
4. **Introducer sheath** (8.5–9 F). This allows for the possibility to insert a temporary pacemaker or a pulmonary artery catheter during or at the end of the procedure.
Apart from the recommended basic and invasive monitoring special intraoperative monitoring can be added:

1. **Transesophageal echocardiography** (TEE) has nearly replaced pulmonary artery catheters (PACs) for intraoperative monitoring and is our standard, the cardiologists typically performs the TEE in TAVI procedures. TEE can provide useful information about aortic valve morphology, LV function, positioning of the prosthesis across the aortic root and can readily identify certain procedural complications.

2. **BIS monitoring**: is a tool that can gauge the depth of anesthesia during the procedure.

3. **Cerebral oximetry** (INVOS).
Some patients may require *inotropic* and/or *vasopressor* support before induction of an anesthesia.

For this purpose we need to prepare infusions of:

1. Adrenaline.
2. Noradrenaline.
3. Phenylephrine.
The choice of induction technique depends heavily on the preference of the anesthesiologist.

A wide range of strategies can be used with success: it’s more a question of *how* than *what* drugs must be used.

Preferable to use more cardiovascular stable drugs induction:

1. Midazolam, sufentanil/fentanyl and atracurium: Generally safe, this strategy may be less attractive when a fast-track approach is preferred.

2. Ketamine (a bolus of 50 mg), fentanyl (100 mcg), and cisatracurium (0.15–0.20 mg/kg): Advantages: arterial pressure is well maintained and proper analgesia is established.

3. Etomidate, fentanyl (100 mcg) and atracurium: Etomidate has a rapid onset of action and is considered to be a cardiovascular stable induction agent.
Review of the use of ketamine during balanced anesthesia (propofol–ketamine technique) developed by Dr. Friedberg for dealing with high risk-patients in the CCL

- **Maintenance** with a continuous infusion of IV propofol at low doses (2-4mg/kg/h), titrating to a BIS of around 60 to 65 with additional boluses of an opioid (fentanyl) and/or ketamine (25 mg, with a limit of 100 mg per case). This has proved to enable a quick wake up with minimal cardiovascular effects.
- On the contrary, some patients receive an infusion of remifentanil at low doses (0.05–0.125 mcg/kg/min).
- **Sevoflurane** as adjuvant, for its cardioprotective/preconditioning properties.

✓ All anesthetic drugs are **titrated carefully** with attention to maintain SVR and CO and the balance between myocardial oxygen demand and supply in the presence of a hypertrophied ventricle and reduced coronary flow.
After induction and hemodynamic stability secured, the cardiologist may begin the TAVI procedure.

Using long acting local anesthesia to avoid discomfort and pain into the recovery period: mixture of lidocaine and bupivacaine with addition of epinephrine.

**Common problems during TAVI are:**

1. **Blood loss**: The amount of blood loss is highly variable, depending on the integrity of the vasculature and technique of the attending cardiologist.

2. **Hypothermia**: During TAVI all patients are actively warmed with air blanket warming systems. The aim is to extubate the patient at the end of the procedure and therefore, a body temperature of $\geq 35.5^\circ$C is obligatory.

3. **Renal**: Patients having preexisting *renal insufficiency* and/or *diabetes mellitus* are at risk of nephrotoxicity and acute renal failure due to the use of radiocontrast media.
   - Cautious prehydration, maintenance of stable hemodynamics can limit the extent of nephrotoxicity.
   - Adjuncts like furosemide, dopamine, and acetylcysteine (1,200 mg in 500mLN/saline over 30 minutes) may be used but their effectiveness is less well established.
Sinus tachycardia and atrial arrhythmias may worsen LV conditions and provoke heart failure—in these cases, cardioversion should be strongly considered.

If a patient becomes hemodynamically unstable secondary to a supraventricular tachyarrhythmia (SVT), cardioversion should be instituted without delay.

In hemodynamically stable patients with SVT, a therapeutic diagnostic maneuver can be attempted (adenosine, vagal stimulation) before further treatment is administered (e.g., esmolol, amiodarone, and electrocardioversion).

When ventricular tachycardia cannot be ruled out, amiodarone is the preferred drug of choice, especially with impaired cardiac function.

Acute bradyarrhythmias, which may induce over distension of the left ventricle are best treated with combined adrenergic agonists and/or with cardiac pacing; overshoot tachycardia should be avoided (atropine can have unpredictable effects).
KFSH Experience

Selection Criteria:
- Based on the international standard recommendation
  1. Logistic Euroscore more than 20
  2. Severe AS
  3. Contraindicated surgery
- At King Faisal hospital our routine use for induction:
  1. Propofol 100 mg ± Ketamine 50 mg
  2. Fentanyl 100 – 200 micg
  3. Esmeron or Atracurium 0.5 – 1 mg/KG
- Maintenance with inhalation anesthesia (sevoflurane) and second dose of:
  1. Fentanyl (100 mcg)
  2. Esmeron OR Atracurium 25 mg
23 cases were done of which:

1. 14 cases transferred to ICU extubated with stable hemodynamics
2. 7 cases with transapical approach were transferred to ICU intubated
3. 2 cases were complicated with dissection of iliac artery and perforation respectively treated with a stent and a laparotomy.

- No mortality on the table
- No stroke
- 1 year mortality: 4 death out of 23 (17.4%)
Phases of TAVI with Potential Consequences for the Anesthesiologist

1. Predeployment
2. Valvuloplasty
3. Positioning and Deployment
4. Post Deployment
Predeployment

- By the cardiologist, access is gained percutaneously through the femoral artery under ultrasound guidance while a pigtail catheter is inserted in the other femoral artery or (via the left radial-brachial artery).

- A bipolar right ventricular transvenous pacing lead is introduced through the femoral vein for rapid ventricular pacing and is tested.

- In this phase maintaining hemodynamic stability and adequate hypnosis and analgesia needs extra attention.

- During the predeployment phase, serious problems can arise from the vascular access site (dissection, rupture, and hemorrhage) or perforation of the left or right ventricle by the extra-stiff guide wire temporary pacing lead, respectively.
TRANSCATHETER HEART VALVE TRANSFEMORAL PROCEDURE

NATIVE VALVE PREDILATION
VALVULOPLASTY

- Rapid Pacing procedure crucial for successful THV deployment

- TIPS AND TRICKS TO REDUCE BURST PACING RISK DURING BAV
  - Practice Rapid Pacing procedure
  - GOAL is to keep rapid pacing time < 15 sec while allowing adequate time for full inflation and deflation of balloon
  - Don't use rapid pacing if BP too low
  - BP NEEDS TO BE ABOVE 100 mmHg BEFORE PACING STARTS... can use pressors if BP low
  - If getting a lot of ectopy, move
    - LV wire
  - Allow for adequate recovery inbetween bursts
  - BE PREPARED TO DEFIBRILLATE

RECOMMENDATION
Observe motion of valve leaflets during BAV inflation to aid in prosthesis positioning

* REFERENCE IN ARTICLE OF INTEREST SECTION OF TRAINING GUIDE
Phases of TAVI with Potential Consequences for the Anesthesiologist

Valvuloplasty

- The goal of Balloon aortic valvuloplasty (BAV):
  1. Adequately dilate the aortic valve annulus to ensure proper seating of the prosthesis within the aortic root
  2. Allows for easier passage of the prosthesis
  3. Permits adequate cardiac output while the prosthesis is positioned across the stenosed aortic orifice.

- BAV is performed under rapid right ventricular pacing (180 – 220 beats per minute)
  1. Rapid pacing may induce cardiac ischemia or arrhythmias and therefore must be kept to a minimum (<15 sec).
  2. Between sequences of rapid pacing, it is imperative that hemodynamic parameters return toward normal (>100 mm Hg.).
Phases of TAVI with Potential Consequences for the Anesthesiologist

- In order to maintain arterial pressure:
  1. Preferable to administer low-dose boluses of epinephrine, 10 to 20 mcg, titrating to effect and repeated if needed.
  2. Administration of a basal infusion of phenylephrine and if needed, additional bolus doses of 100 to 200 mcg.
  3. Ephedrine or norepinephrine may be alternatives. An infusion of norepinephrine is sometimes used.

- Complications associated with BAV:
  1. Coronary ostial obstruction or embolization
  2. Aortic root rupture
  3. Myocardial depression
  4. Arrhythmias, conduction blocks
  5. Severe aortic regurgitation
  6. Stroke

- Electrocardiogram and TEE can be useful to rule out several of these complications.
Native Valve Predilation

RAPID PACING CONSIDERATIONS:
- BAV and opportunity to practice rapid pacing procedure
- Pacing rates from 150-220 bpm sufficient
- GOAL is to keep rapid pacing time < 15 sec while still allow adequate time for full inflation and deflation of balloon
- Don’t use rapid pacing if BP too low
- BP must be above 100 mmHg BEFORE PACING STARTS.. can use pressors if BP low
- Allow for adequate recovery in between bursts
- BE PREPARED TO DEFIBRILLATE

Observe motion of valve leaflets during BAV inflation to aid in prosthesis positioning

Begin pacing, wait for 1:1 conduction and SPB < 50 mmHg

SPB < 50mmHg (approximately) for Balloon Inflation

Recovery back to 100 mmHg

Balloon successfully inflated
Phases of TAVI with Potential Consequences for the Anesthesiologist

Positioning and Deployment

- Deployment of balloon-expandable devices requires rapid ventricular pacing to significantly diminish cardiac output and ensure stable position of the prosthesis during valve deployment.

- Deployment of self-expanding devices does not require rapid ventricular pacing.

- While positioning the prosthesis across the aortic root, the large diameter delivery catheters can obstruct blood flow and create hemodynamic instability. The only treatment is urgent deployment of the prosthesis, which immediately reduces LV afterload and myocardial oxygen demand. During this crucial phase, the cardiology team should be very pragmatic and avoid repeated aortograms and/or wasting of time.
Phases of TAVI with Potential Consequences for the Anesthesiologist

- Potential problems in this phase of TAVI can include:
  1. Incorrect placement (too high or too low)
  2. Device embolization distally into the aorta or proximally into the left ventricle
  3. Central or paravalvular regurgitation
  4. Coronary ostial obstruction
  5. Arrhythmias
  6. AV block
  7. Impingement of the anterior mitral valve leaflet affecting its function

- TEE can be helpful to diagnose and/or avoid these complications, assess LV function, degree and etiology of aortic regurgitation, and the need for further dilation or implantation of a second prosthesis (valve-in-valve).
PROSTHETIC VALVE DELIVERY

TIPS AND TRICKS TO POSITIONING EDWARDS SAPIEN THV

- Injections of contrast through the supra-aortic pigtail catheter can help with positioning.
- Use different fluoroscopic views if uncertain about positioning (AP and LAO).
- Fluoroscopic imaging of valvular calcium, ascending aortography and TEE optimizes THV positioning.
- Aortogram during rapid pacing can be useful.

THV moves cranial when deployed.

THIS VALVE IS POSITIONED TOO AORTIC...
CORRECT PLACEMENT: Axial placement of valve in annulus should be least 1/2 to 2/3 of THV in ventricle. There are NO rotational requirements.
CONSIDERATIONS TO POSITIONING THV

- Once native valve is crossed separate Balloon valve assembly/Retroflex Catheter to make final positioning maneuvers
- THV tends to move cranial up to 5mm during deployment
- LV guidewire MUST be maintained
- Verify THV frame is perpendicular to axis of annulus

Retract RetroFlex catheter into aorta before deployment

Observe calcium during valve placement of THV

Maintain LV position of guide wire

CAUTION

VF or ischemia can occur during rapid ventricular pacing
TRANS catheter heart valve transfemoral procedure

Prosthetic valve delivery

Deployment of Edwards Sapien THV

Pacing sequence

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Words</th>
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| Primary physician says | "pacemaker ready"
| Pacemaker operator says | "pacemaker ready"
| Primary physician says | "pacemaker on"
| Pacemaker operator says | "pacemaker on"
| Pacemaker operator turns on pacemaker | "inflating"
| once SBP < 50mmHg | "inflating"
| Secondary physician says | "deflating"
| balloon fully inflated by secondary physician then deflated | "deflating"
| Secondary physician says | "pacemaker off"
| secondary physician pulls BAV catheter out of native valve | "pacemaker off"
| Primary physician says | "pacemaker off"
| when sees balloon out of valve | "pacemaker off"
| Pacemaker operator repeats | "pacemaker off"

Deployment of bioprosthesis

- Deploy valve with continuous, forceful and UNIFORM balloon inflation
  - In cases of non-uniform expansion of the valve due to calcification of the annulus, re-inflate balloon and re-expand
- Pacing MUST be continued until balloon fully deflated AND when no more contrast is visible in the balloon
  - Terminating pacing too quickly after deployment (before balloon is fully deflated) may cause migration of THV
- Inflate when 1:1 capture, conduction established AND SBP reduction established to <50 mmHg

Caution

VF or ischemia can occur during rapid ventricular pacing

Assure blood pressure is high enough (>100mmHg) before starting rapid pacing
Phases of TAVI with Potential Consequences for the Anesthesiologist

Post Deployment

- Final assessment of device position and function.
- Integrity of vessel repair and the absence of vascular complications (perforation, dissection and occlusion) can be assessed with angiography.
- Delivery system is removed and the vascular access site is closed.
- At this stage, some patients experience an increase in cardiac output and blood pressure requiring a decrease or discontinuation of vasopressor / inotropic agents.
VERIFICATION OF PROSTHETIC VALVE POSITION AND MEASUREMENTS

POST DEPLOYMENT ASSESSMENTS

- Position of THV
- Aortic regurgitation; severity, origin
- Requirement of balloon dilatation and reassess for thrombus
- Re-evaluate LV function, MR
- Evaluate for pericardial effusion
- Descending aorta and aortic arch
- Coronary flow

CONSIDERATION

Central AI typically improves over 24 hours
TRANSCATHETER HEART VALVE TRANSFEMORAL PROCEDURE

VERIFICATION OF PROSTHETIC VALVE POSITION AND MEASUREMENTS
POST DEPLOYMENT ANGIOGRAPHY

POST DEPLOYMENT ANGIOGRAPHY CONSIDERATION

- Perform aortogram with wire still in the left ventricle to evaluate aortic regurgitation

Stiff wire tends to exacerbate AR

Aortogram without a guidewire to assess AR
TRANSCATHETER HEART VALVE TRANSFEMORAL PROCEDURE

VERIFICATION OF PROSTHETIC VALVE POSITION AND MEASUREMENTS
POST DEPLOYMENT ANGIOGRAPHY

TIPS AND TRICKS

- Perform iliac angiogram post-procedure and after large sheath removal

Normal flow shown on iliac angiogram
POST DEPLOYMENT TEE CONSIDERATIONS

- Some paravalvular leak expected post deployment
- Central leak typically improves within 24 hours
- Consider repeat balloon expansion if paravalvular leak is severe. Balloon expansion should be done without adding volume to syringe.

TEE shows mild paravalvular leak following valve deployment
Patients undergoing TAVI procedure should be transferred to an ICU facility.

The stability and function of the temporary pacemaker lead should be verified prior to transfer.

Upon arrival to ICU:
1. Vital signs and neurological status should be recorded and followed at regular intervals.
2. All access sites should be routinely checked for signs of bleeding.
3. Blood loss may not be apparent in cases of:
   - Retroperitoneal bleeding
   - Pericardial effusions
   - Hemothorax
4. A peripheral vascular exam should confirm normal distal pulses and perfusion of the extremities.

Most often patients are transferred to the ward the morning after the procedure.
Anesthesia Protocol for Trans catheter Aortic Valve implantation (TAVI) at KFSH (IPP)

1. All patients shall be evaluated by an Anesthesiologist by a preoperative assessment.

2. If premedication is needed: Dose of per oral premedication shall be carefully considered. It is the responsibility of the Anesthesiologist to carefully titrate preoperative sedative intravenously. The Anesthesiologist shall ensure that oxygen is available if patient is sedated.

3. Preoperative Antibiotic: Kefzol 1g shall be given at induction of Anesthesia. If the patient is allergic to Penicillin alternative Antibiotic shall be decided by the surgeon.

4. Patients shall be monitored by Routine cardiac monitoring/standard basic ASA monitoring including oxygen saturation and capnography, insertion of Radial arterial line and continuous arterial pressure, triple lumen central line with continuous central venous pressure and continuous assessment of urinary output.
Anesthesia Protocol for Trans catheter Aortic Valve implantation (TAVI) at KFSH (IPP)

5. Introducer sheath (8.5–9 F). This allows for the possibility to insert a temporary pacemaker or a pulmonary artery catheter during or at the end of the procedure.

6. Transesophageal echocardiography (TEE).

7. Defibrillator Pads shall be applied on the patient and attached to the defibrillator.

8. Anesthetic induction agents shall be titrated to the individual patient’s need:
   - Fentanyl, Sufentanyl, Ketamine, Midazolam, Propofol, Atracurium / Esmeron, Inhalational agents may be used.

   Consideration taken to possible extubation at the end of the procedure.

5. For maintenance of anesthesia: Opioids + inhalational / Propofol / Midazolam may be used.
Anesthesia Protocol for Trans catheter Aortic Valve implantation (TAVI) at KFSH (IPP)

10. Vasoactive medications to rapidly manipulate heart rate, optimize preload, contractility and systemic vascular resistance shall be available in syringes for iv bolus administration
   a. Epinephrine 10 µg / ml
   b. Neosynephrine 100 µg / ml
   c. Nitroglycerine 50 µg / ml
   d. Ephedrine 5 mg / ml

11. Other Perioperative Vasoactive medications shall be titrated to the individual patient’s need. The following therapies shall be available/considered
   a. Milrinone 0.375 to 0.75 µg/kg/min
   b. Epinephrine 0.01 to 0.1 µg/kg/min
   c. Norepinephrine 0.01 to 0.1 µg/kg/min
   d. Nitroglycerin 0.1 to 0.5 mcg/kg/min

The possible need for PgE1, i.NO shall be considered by the consultant Anesthesiologist.
Anesthesia Protocol for Trans catheter Aortic Valve implantation (TAVI) at KFSH (IPP)

12. Low dose Vasopressin (0.03-0.1U/min) or Methylene blue may be added at the discretion of the Consultant Anesthesiologist, if systemic vascular resistance is low despite adjustment of the above drugs.

13. Hypothermia shall be avoided. Warm air blankets and iv fluid warmers shall be used.

14. Preparation shall be made for possible major blood loss, occult in cases of retroperitoneal blood loss. Rapid transfusion device shall be immediately available. Cardiopulmonary bypass may be required.

15. Heparin 150-300 unit/kg should be given to have ACT ≥ 250 before the inflation of the balloon to dilate aortic valve.

16. Before rapid pacing is induced for valvuloplasty and deployment of the prosthetic valve, hemodynamic parameters shall be normal with normal coronary perfusion pressure.
17. Patients with preexisting renal insufficiency and/or diabetes mellitus are at risk for development of acute renal failure due to the use of radiocontrast media. The anesthesiologist shall consider careful prehydration and maintenance of stable hemodynamics to limit the extent of nephrotoxicity.

18. A verbal systematic professional report should be given by the Anesthesiologist to the responsible CCU/CSICU nurse as per ISBAR format (Appendix A).

19. Upon arrival in the CCU / CSICU, the patient shall be re-evaluated and a verbal systematic professional report should be given by the Anesthesiologist to the responsible ICU physician as per ISBAR format (Appendix A).

20. The Anesthesiologist shall remain in the CCU / CSICU until the patient vital signs are stable and the CCU / CSICU accepts responsibility for the care of the patient.
Transcatheter Aortic Valve Implantation

Thank you