Optimization of Anticoagulant Use After Mitral Mechanical Valve Replacement: Challenges and Strategies in Clinical Practice

Setiawan Winarso

Supervisor:

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Introduction

Mechanical mitral valve replacement is crucial for severe mitral stenosis, often due to rheumatic heart disease.

It improves cardiac function and patient quality of life.

Long-term success depends on effective anticoagulant therapy to prevent thromboembolic and bleeding complications.

Mechanical valves carry high thrombogenic risks, requiring warfarin and regular INR monitoring.

This case report discusses challenges in anticoagulation optimization, bridging therapy, and complication prevention.

Offers evidence-based strategies to balance thromboembolism prevention and bleeding risk management.

3

Case Illustration

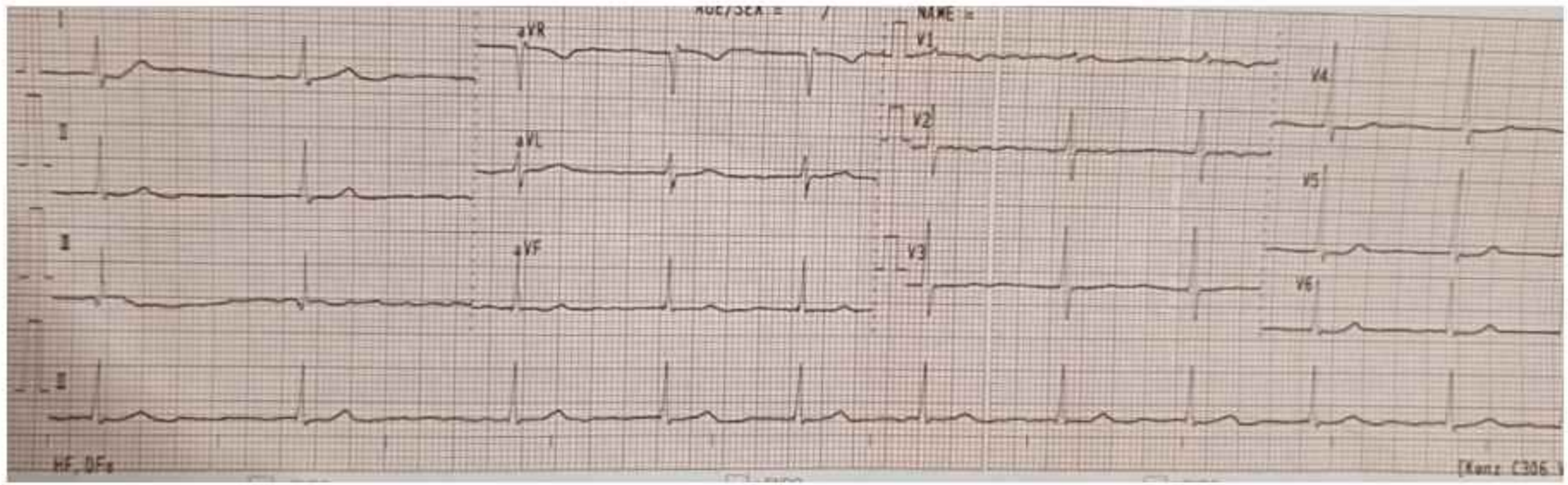
Anamnesis

- A 63-year-old woman presented with intermittent palpitations that had been occurring over the past month. Shortness of breath (+), DOE (+), Orthopnea (+), PND (+). The patient first experienced palpitations and shortness of breath in 2008. She did not report dizziness, syncope, or orthopnea. Chest pain (-).
- History of stroke 2 months ago.
- History of Balloon Mitral Valvuloplasty (BNV) at Surabaya on 2011
- History of HT (-)
- History of DM (-)
- History of smoking (-)
- History of cardiovascular disease in the family (-)

Physical examination

- Conjunctivae anemic (-), sclera icteric (-)
- JVP R+3 cm H2O
- Vesicular breath sounds, rhonchi (-), wheezing (-), irregular heart sound, diastolic murmur 2/4 at apex
- Warm peripheries, capillary refill time < 2 seconds, edema (-)

EKG



Laboratorium

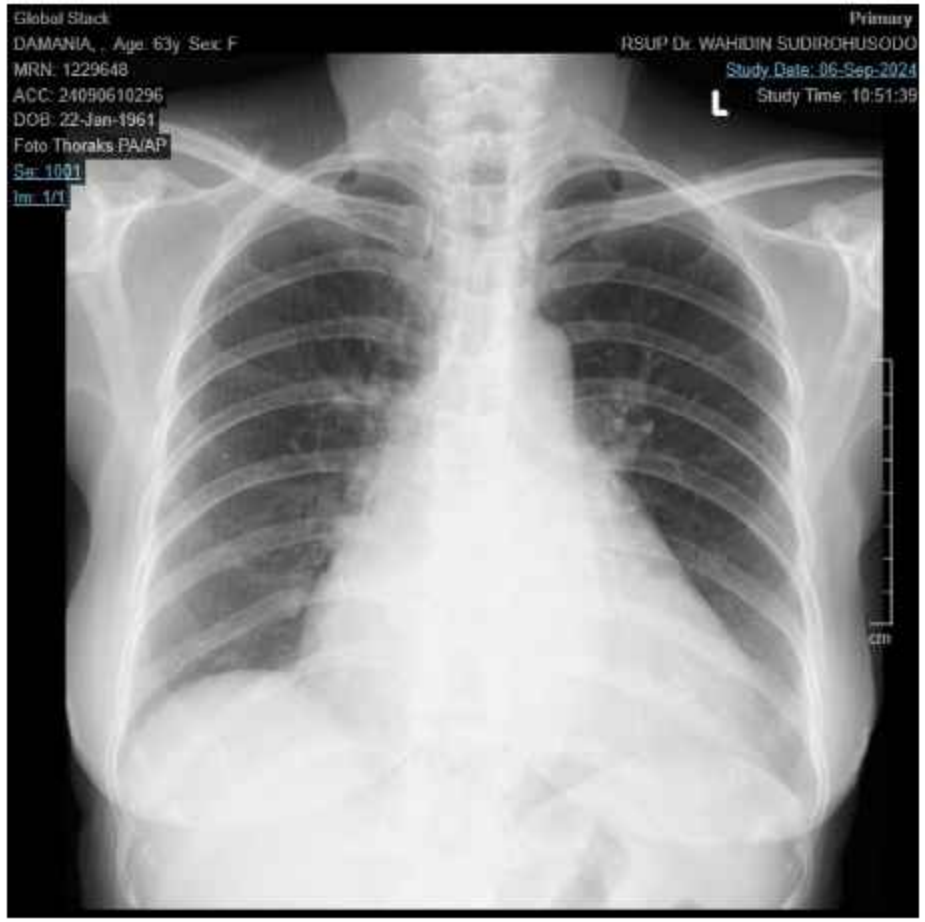
Nama	: DAMANIA	**Tgl. Registrasi**	: 19/11/2024 09:52:34
Sex / Tgl Lahir	: Perempuan / 22-01-1961	**Tgl. Hasil**	: 19/11/2024 15:30:34
No. Lab	: 101160100241119002B	**Unit Pengantar**	: Poliklinik Thorax Dan Vaskular
Diagnosa	: PRD MVR	**Dokter Penjuk**	: dr. JAYARAJ S KUSUMAWIGUNA, Sp.BTKV Subsp. VE (K), M.Kes

PEMERIKSAAN	HASIL	NILAI RUJUKAN	SATUAN
HEMATOLOGI			
Hematologi Rutin			
Hematologi Rutin Automatik			
WBC	6.8	4.00 - 10.0	10^3/ul
RBC	3.90	4.00 - 6.00	10^6/uL
HGB	10.9	12.0 - 16.0	g/dl
HCT	34	37.0 - 48.0	%
MCV	87	80.0 - 97.0	fL
MCH	28	26.5 - 33.5	pg
MCHC	32	31.5 - 35.0	g/dl
PLT	277	150 - 400	10^3/ul
RDW-SD	45.2	37.0 - 54.0	fL
RDW-CV	14.1	10.0 - 15.0	%
PDW	8.3	10.0 - 18.0	fL
MPV	8.8	6.50 - 11.0	fL
PCT	0.24	0.15 - 0.50	%
NEUT	60.3	52.0 - 75.0	%
LYMPH	33.0	20.0 - 40.0	%
MONO	6.8	2.00 - 8.00	%
EO	4.3	1.00 - 3.00	%
BASO	0.6	0.00 - 0.10	%
LED I	35	(L < 10, P <20)	mm
Koagulasi			
Waktu Prothrombine (PT) _			
INR	2.18	-	
PT	21.9	10-14	detik
APTT _			
APTT	36.8	22.0 - 30.0	detik
KIMIA DARAH			
Glukosa			
Glukosa Puasa			
GDP	94	110	mg/dl
Glukosa 2 Jam PP			

No. RM	: 01229648	**No. Registrasi**	: 24111900824
Nama	: DAMANIA	**Tgl. Registrasi**	: 19/11/2024 09:52:34
Sex / Tgl Lahir	: Perempuan / 22-01-1961	**Tgl. Hasil**	: 19/11/2024 15:09:29
No. Lab	: 101160100241119002B	**Unit Pengantar**	: Poliklinik Thorax Dan Vaskular
Diagnosa	: PRD MVR	**Dokter Penjuk**	: dr. JAYARAJ S KUSUMAWIGUNA, Sp.BTKV Subsp. VE (K), M.Kes

PEMERIKSAAN	HASIL	NILAI RUJUKAN	SATUAN
GD2PP	114	< 200	mg/dl
Fungsi Ginjal			
Ureum			
ureum	41	10 - 50	mg/dl
Kreatinin			
Kreatinin	0.75	L(< 1.3),P(<1.1)	mg/dl
Fungsi Hati			
GOT			
SGOT	23	< 38	U/L
GPT			
SGPT	19	< 41	U/L
Elektrolit			
Elektrolit _			
Natrium	141	136 - 145	mmol/l
Kalium	4.0	3.5 - 5.1	mmol/l
Klorida	106	97 - 111	mmol/l
Analisa Gas Darah			
Analisa Gas Darah			
PH	7.493	7.35 - 7.45	
PO2	160.6	80.0 - 100.0	mmHg
PCO2	28.4	35.0 - 45.0	mmHg
SO2	99.9	95 - 98	%
HCO3	22.0	22 - 26	mmol/l
BE	-1.5	- 2 s/d + 2	mmol/l
ctO2	17.1	15.8-22.3	
ctCO2	22.9	23-27	mmol/l

Chest X ray



RS Wahidin Sudirohusodo

Jalan Perintis Kemerdekaan Km. 11 Tamalanrea Makassar

HASIL PEMERIKSAAN RADIOLOGI

No. RM	: 01229648	**No. Registrasi**	: 2409060787
Nama	: DAMANIA	**Tgl. Registrasi**	: 06/09/24 10:51
Sex / Tgl Lahir	: Perempuan / 22-01-1961	**Tgl. Hasil**	: 06/09/24 11:26
Unit Pengantar	: Poli Jantung 2	**Nama Tindakan**	: Foto Thoraks PA/AP
Dokter Perujuk	: dr. AZ HAFID NASHAR, Sp.JP(K)	**Diagnosa**	: MR, MS

KLINIS :

MR, MS

HASIL PEMERIKSAAN :

Foto Thorax PA :

- Corakan bronchovascular dalam batas normal
- Tidak tampak infiltrat dan konsolidasi pada kedua paru
- Cor : membesar CTR 0.65, apex tertanam (LVE), aorta normal
- Kedua sinus dan diafragma baik
- Tulang-tulang intak
- Jaringan lunak sekitar baik

KESAN PEMERIKSAAN :

Cardiomegaly

USUL PEMERIKSAAN :

-

MAKASSAR, 06-09-2024 11:26:11

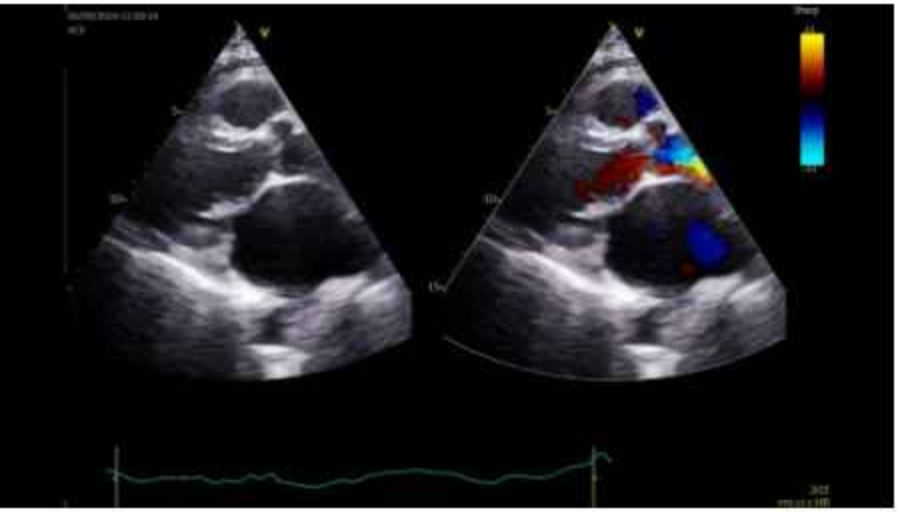
Konsulen

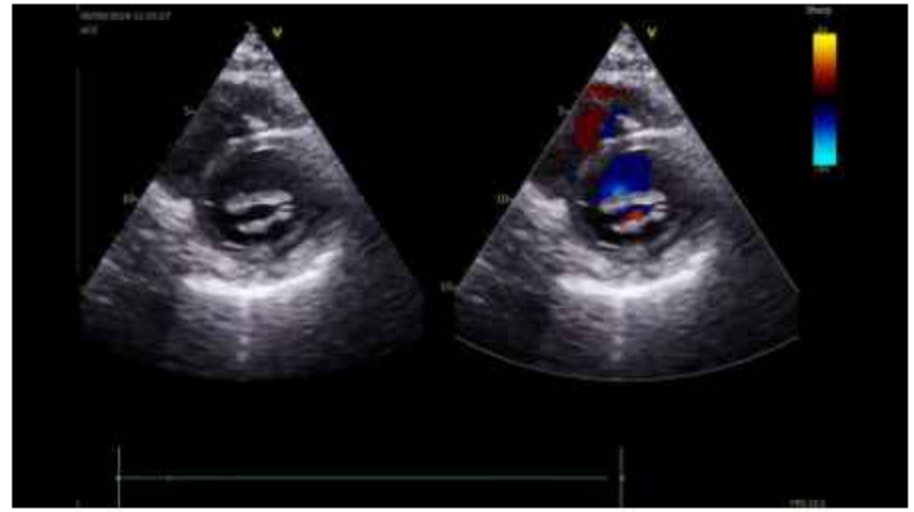
dr. JUNUS ASIU BULU BAAN, Sp.Rad (K)

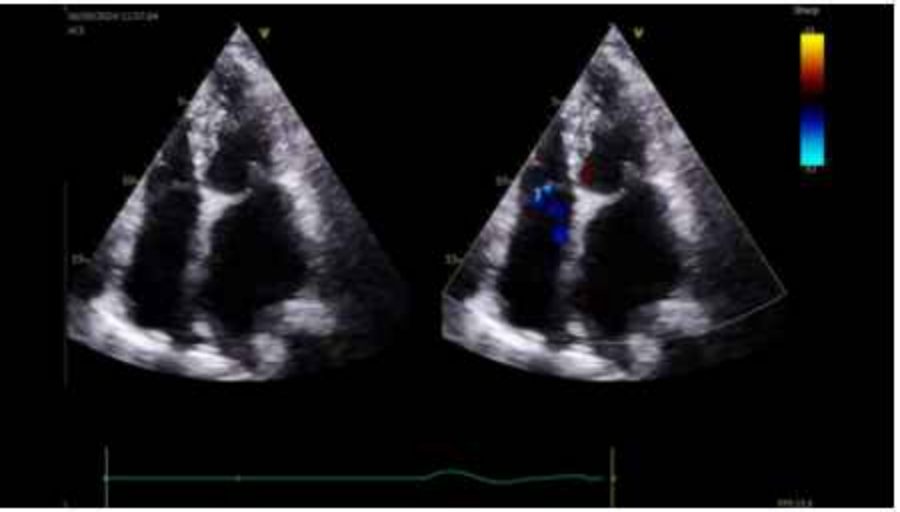
BTK, SS

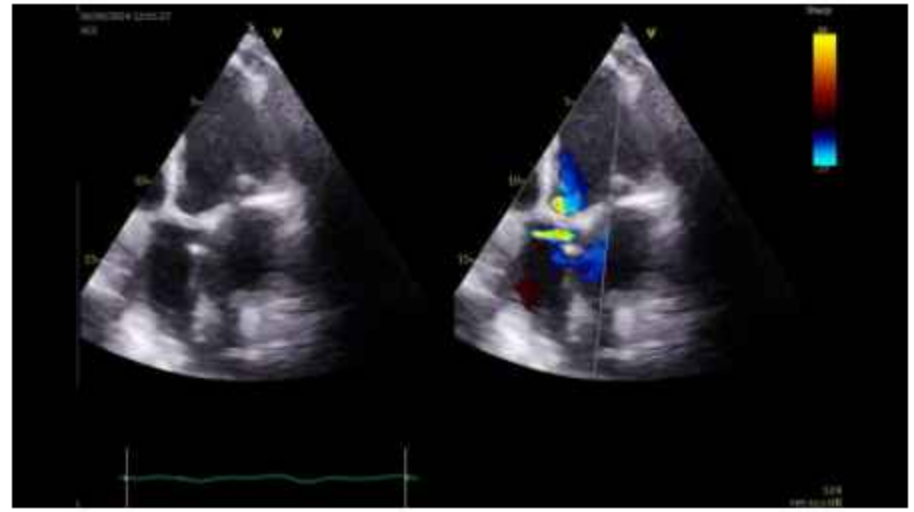
dr. Andrewi cr. Dharmanadi

Echocardiography









RS WAHIDIN SUDIROHUSODO

LAPORAN TRANSTHORACIC ECHOCARDIOGRAM

Nama	: DAMANIA
Tanggal Lahir	: 22-01-1961
No. RM	: 01229648

Ruangan	: Echo dan Vaskuler Doppler
Dokter	: dr. AZ HAFID NASHAR, Sp.JP(K)

Tanggal Tindakan	Jam Mulai	Jam Selesai	Durasi Tindakan
04-09-2024	11.01	12.00	00.58

Klinis : MS SEVERE POST BMV
Operator : WP - RO

Measurement on Atrial fibrillation

1. Cardiac Valves:
- Mitral: Moderate Mitral Stenosis (MV PHT 171 ms, MVA by PHT 1.3 cm2, MVA Planimetry 1.3 cm2, MV mean PG 3.73 mmHg, measured on Atrial fibrillation HR 67 bpm) Wilkins Score 11 (3-3-3-2) due to Cormier score group 2 AHA revised stage B
- Aorta: 3 cuspis, mild to moderate AS (AV Vmax 2.5 m/s, AV mean PG 11.08 mmHg, AVA by Continuity equation 1.2 cm2, AVA by planimetry 1.3 cm2, SVI 47.4 ml/m2) Calcified NCC and RCC grade 3 with restricted motion, no apparent commisural fusion. Normal flow, low Gradient Aortic Stenosis due to Degenerative Process
- Mild Aortic Regurgitation (Regurgitant Jet Width < 1/3 of LVOT, AR PHT 618 ms)
- Tricuspid: Mild Tricuspid Regurgitation with central jet (regurgitant Jet Length Area <20 % of RA, TR Vmax 2.27 m/s, TR maxPG 20.72) with low Probability of Pulmonary Hypertension
- Pulmonal: Trivial Pulmonic Regurgitation, PvAcct : 159 ms

2. Dimension of cardiac chambers:
- LA: Dilation, LA major 7.7 cm, LA minor 5.6 cm, LAVI 115.82 ml/m2
- LV: Normal, LVIDd 4.9 cm, LVIDs 3.5 cm
- RA: Dilation, RA mayor 7.3 cm, RA minor 3.4 cm RA Area: 20.2 cm2
- RV: Normal, RVDB 3.7 cm, RVDM : 2.5 cm , RVDL cm
- Aorta: Ao 2.7 cm, LA 5.0 cm, LA/Ao 1.85

3. Normal LV systolic function, EF 57% (TEICH), EF 56% (BIPLANE)

4. Normal RV systolic function, TAPSE 2.0 cm, S' lateral 12 cm/s

5. Left Ventricular Hypertrophy: (+) Concentric (LVMI 187.78 g/m2, RWT 0.61)

6. Regional Wall Motion: Global normokinetik

7. eRAP: 8 mmHg (IVC exp: 1.8 cm, IVC insp: 1.5 cm)

8. LV Diastolic function : E/A on Atrial fibrillation

Conclusion:
Severe Mitral stenosis wilkin score 11 due to RHD
Mild tricuspid Regurgitation with low probability of PH
Mild to moderate Aortic stenosis due to degenerative process
Mild aortic regurgitation
Normal LV systolic function, EF 57% (TEICH), EF 56% (BIPLANE)
Normal RV systolic function, TAPSE 2.0 cm, S' lateral 12 cm/s
RA and LA Dilatation with Concentric LVH
Global normokinetic

Assessment

Severe Mitral Stenosis post BMV 2011

Atrial Fibrillation Normoventricular Response

Plan

- Spironolactone 25 mg/24 hours/oral
- Digoxin 0.25 mg/24 hours/oral
- Furosemide 40 mg/24 hours/oral
- Warfarin 2 mg/24 hours/oral (Postponed H-5 before surgery)
- Heparin 60 IU/kg/iv, Continue 12 IU/kg/hour/syringe pump (stop 6 hours before surgery)
- MV Replacement with mechanical valve

Mitral Valve Replacement Report

RS WAHIDIN SUDIROHUSODO

LAPORAN OPERASI

Nama : DAMANIA

No. RM : 01220648

Diagnosis Pra Bedah : MITRAL STENOSIS POST BMV + MODERATE MITRAL REGURGITATION

Diagnosis Pasca Bedah : MITRAL STENOSIS POST BMV + MODERATE MITRAL REGURGITATION

Jaringan Yang Dieksisi : Tidak ada

Jenis Transfusi : Tidak ada

Jumlah Transfusi : Tidak ada

Laporan Operasi

RS WAHIDIN SUDIROHUSODO

LAPORAN OPERASI

Nama : DAMANIA

Tanggal Lahir : 22-01-1981

No. RM : 01220648

vent off

22. Weaning CPB sampai dengan off, dekanulasi kanul cardioplegia antegrade, dekanulasi left vent
23. Protamin in, dekanulasi IVC dan SVC, setelah protamin habis dekanulasi aorta
24. Evaluasi dan kontrol perdarahan dari lapangan operasi
25. Pasang drain substernal 28 fr dan drain intra pericard 16 fr
26. Pericard di tutup sebagian, sternum dijahit dengan sternal wire, 2S, subcutis dan kulit di jahit lapis demi lapis dengan jahitan continuous
27. Operasi selesai

AOX: 43 menit

CPB: 49 menit

Transfusi:

Packed Red Cell: 676 mililiter

Fresh Frozen Plasma: 569 mililiter

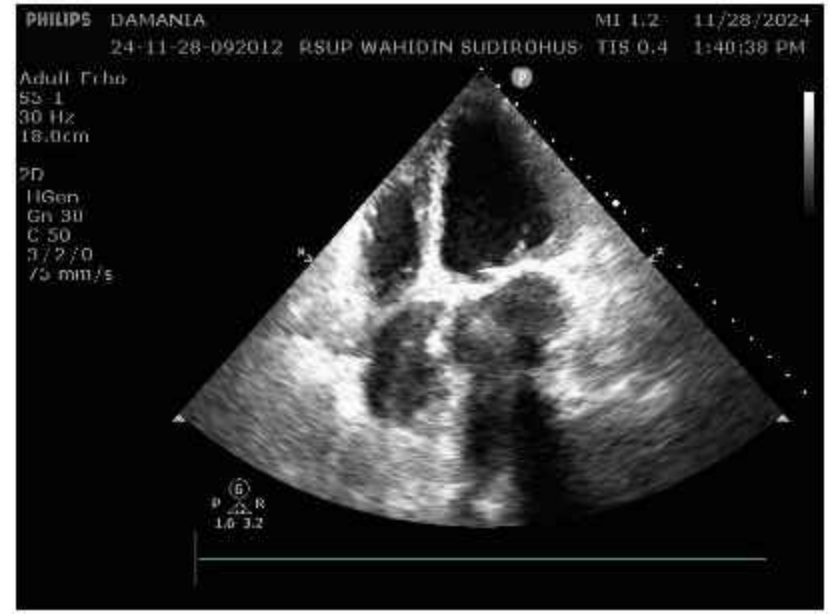
Trombosit Consentrate: 240 mililiter

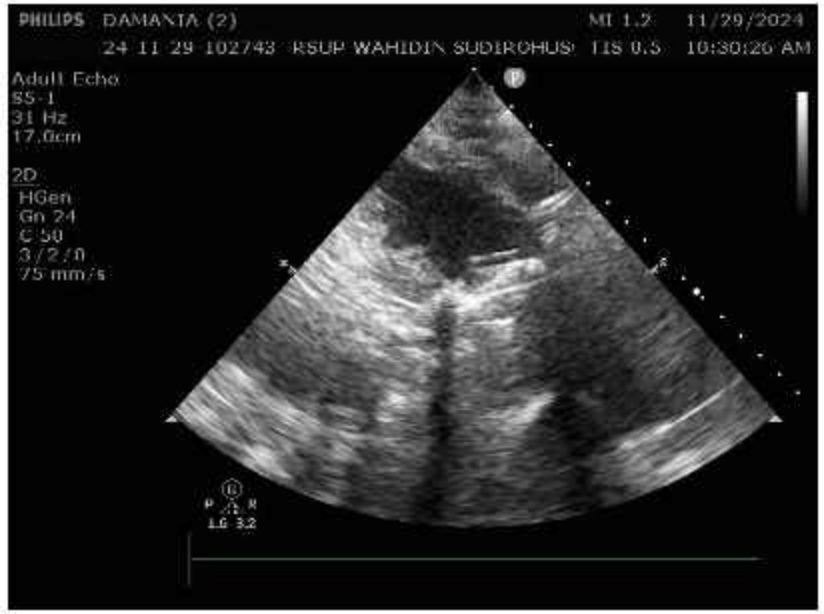
On-X® Valves

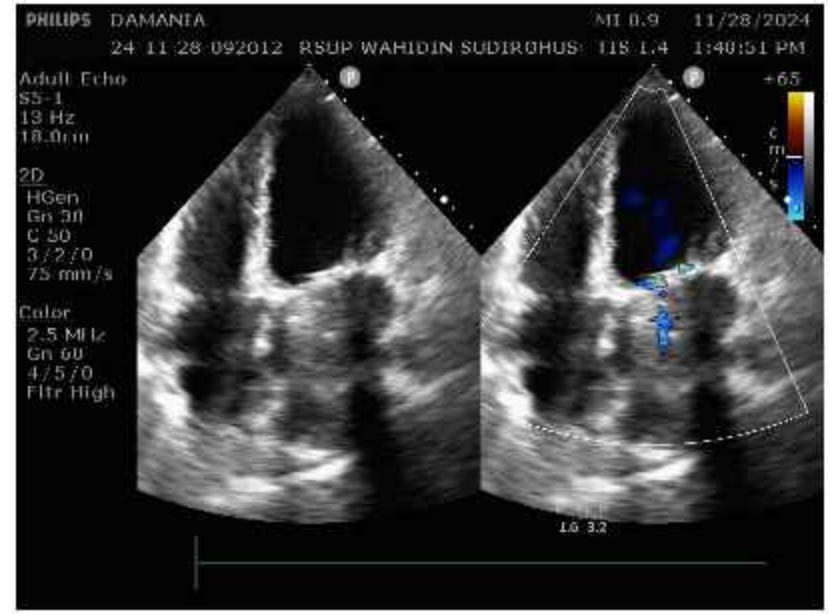
28-11-2024

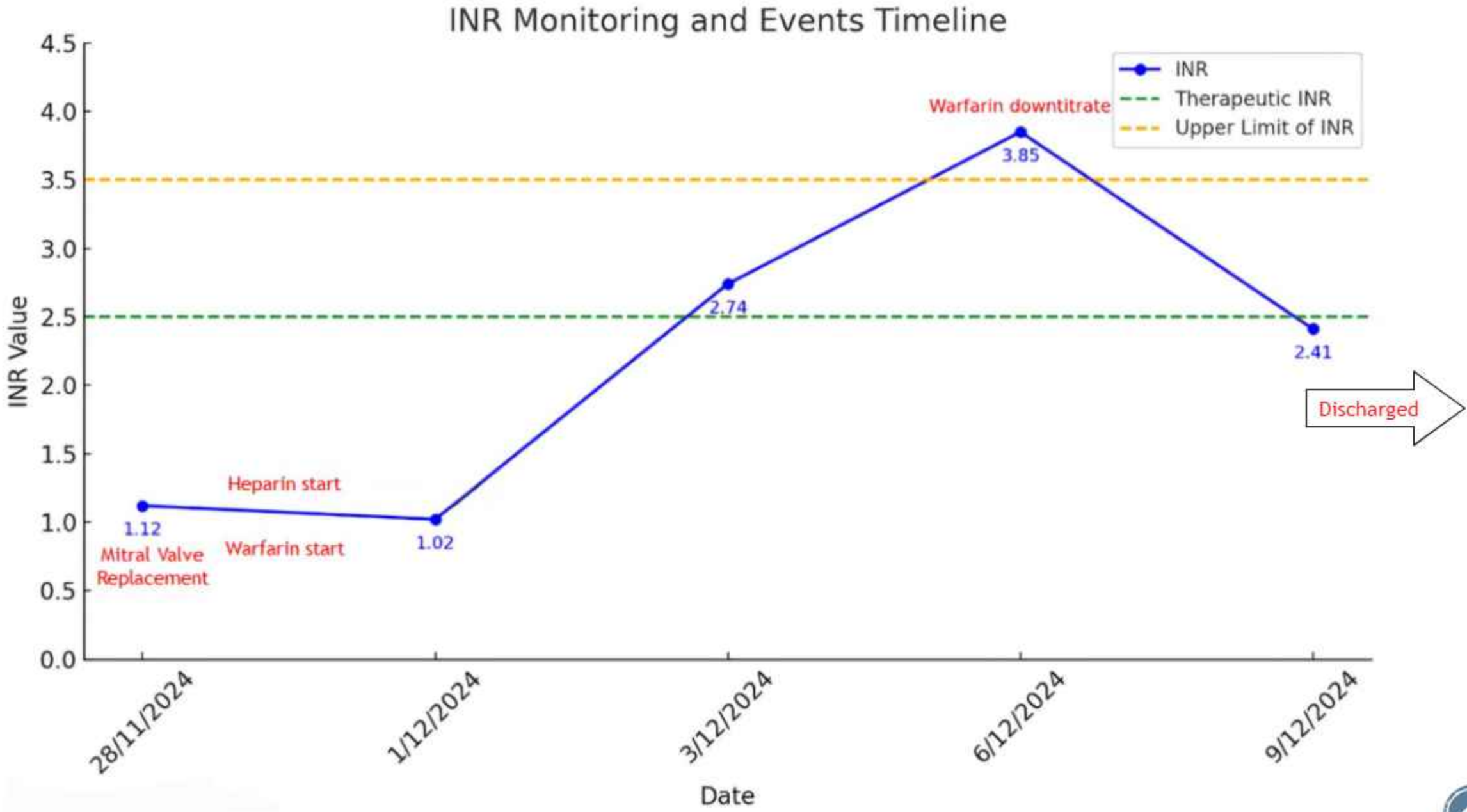
Tanda Tangan :

Echocardiography Post Surgery








INR Monitoring and Events Timeline
INR
Therapeutic INR
Upper Limit of INR
INR Value
Date
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
28/11/2024
1/12/2024
3/12/2024
6/12/2024
9/12/2024
1.12
1.02
2.74
3.85
2.41
Mitral Valve Replacement
Heparin start
Warfarin start
Warfarin downtitrate
Discharged

Discussion

Historical Context of Prosthetic Heart Valves

1

1960

Harken and Starr independently replace aortic valves with ball-valve prostheses, marking the beginning of heart valve replacement surgery.

2

1970s

Introduction of bioprosthetic valves, including the first porcine valve (Hancock valve), offering an alternative to mechanical valves.

3

1980s-Present

Continuous improvements in valve design, materials, and anticoagulation strategies, leading to better outcomes and quality of life for patients.

Types of Prosthetic Heart Valves

Bioprosthetic Valves

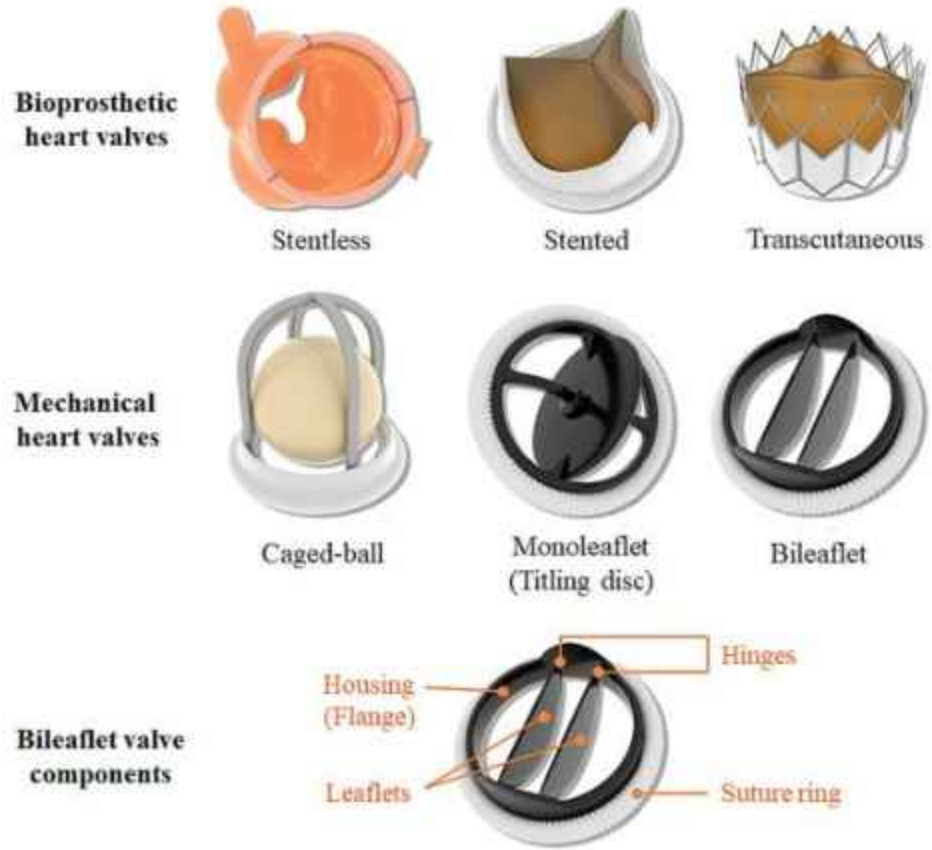
Derived from animal tissue (porcine or bovine). More physiological and doesn't require long-term anticoagulation. Recent improvements have enhanced durability.

Homografts

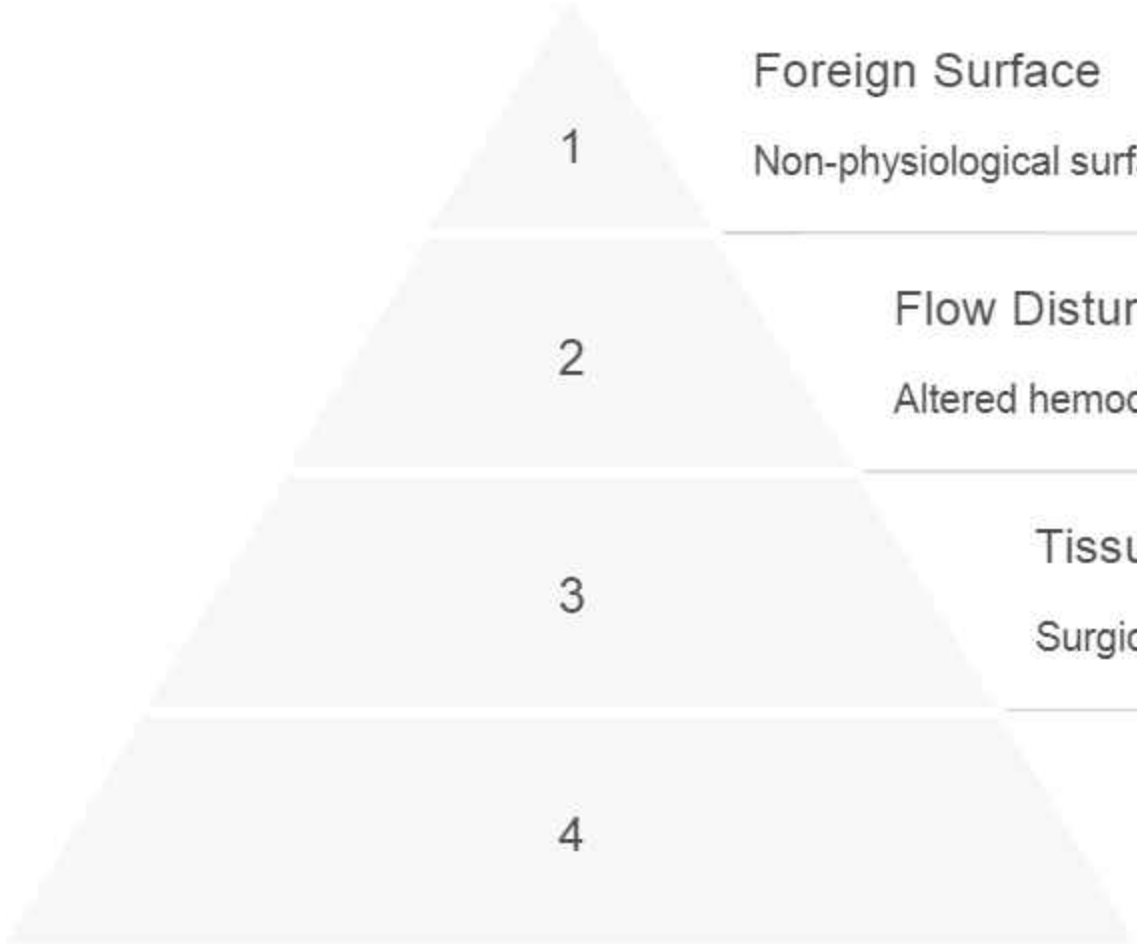
Human heart valves obtained from donors. Offer excellent hemodynamics and low thrombogenicity but limited availability.

Mechanical Valves

Includes caged-ball, single leaflet (tilting-disk), and bileaflet designs. Made from metal, carbon, and/or synthetic materials. More durable but requires lifelong anticoagulation.



Thrombogenicity of Mechanical Valves



1

Foreign Surface

Non-physiological surface activates coagulation cascade

2

Flow Disturbances

Altered hemodynamics promote platelet activation

3

Tissue Damage

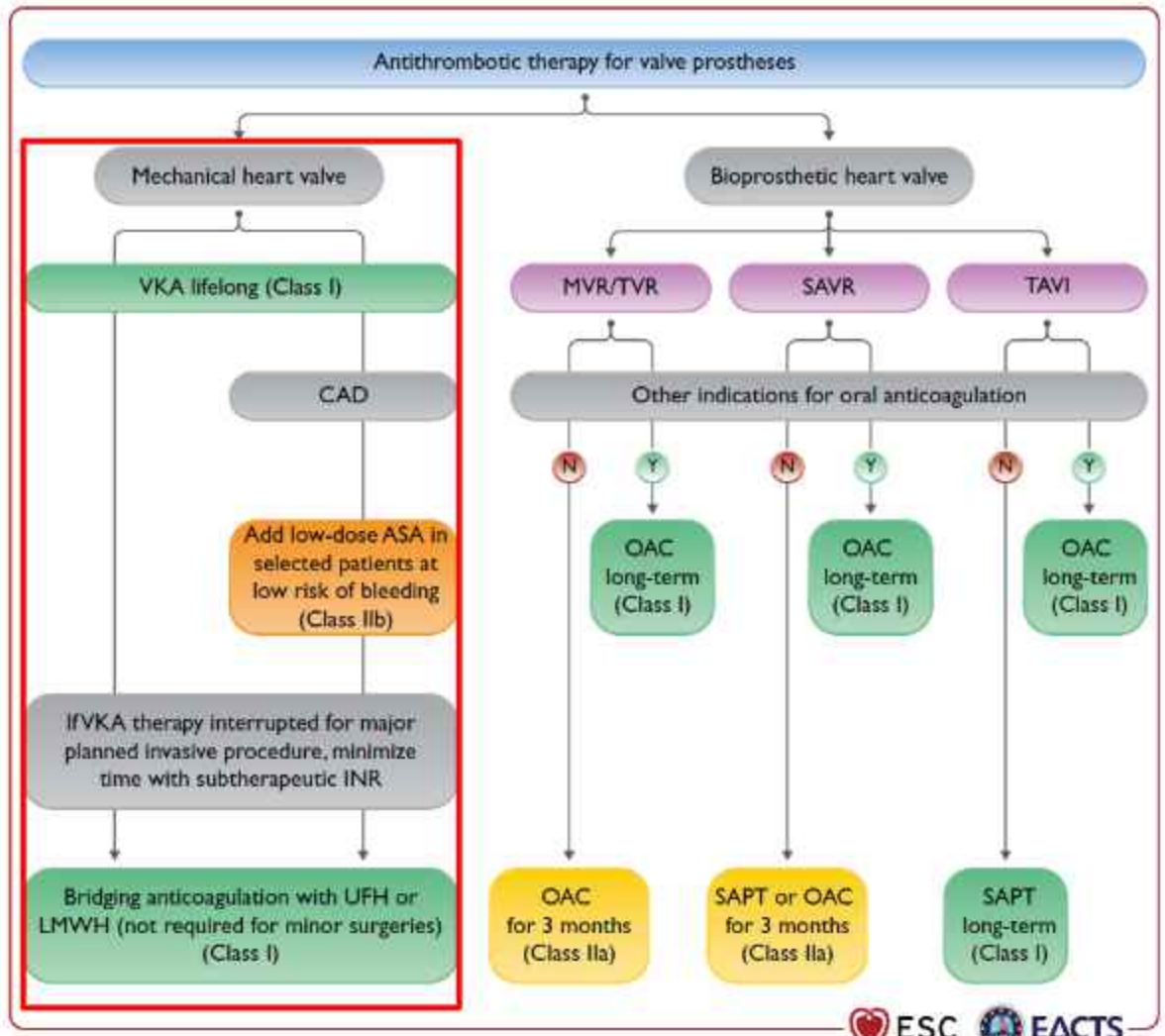
Surgical trauma exposes thrombogenic factors

4

Endothelialization

Incomplete coverage leaves areas prone to thrombosis

Antithrombotic Therapy for Valve Prosthesis



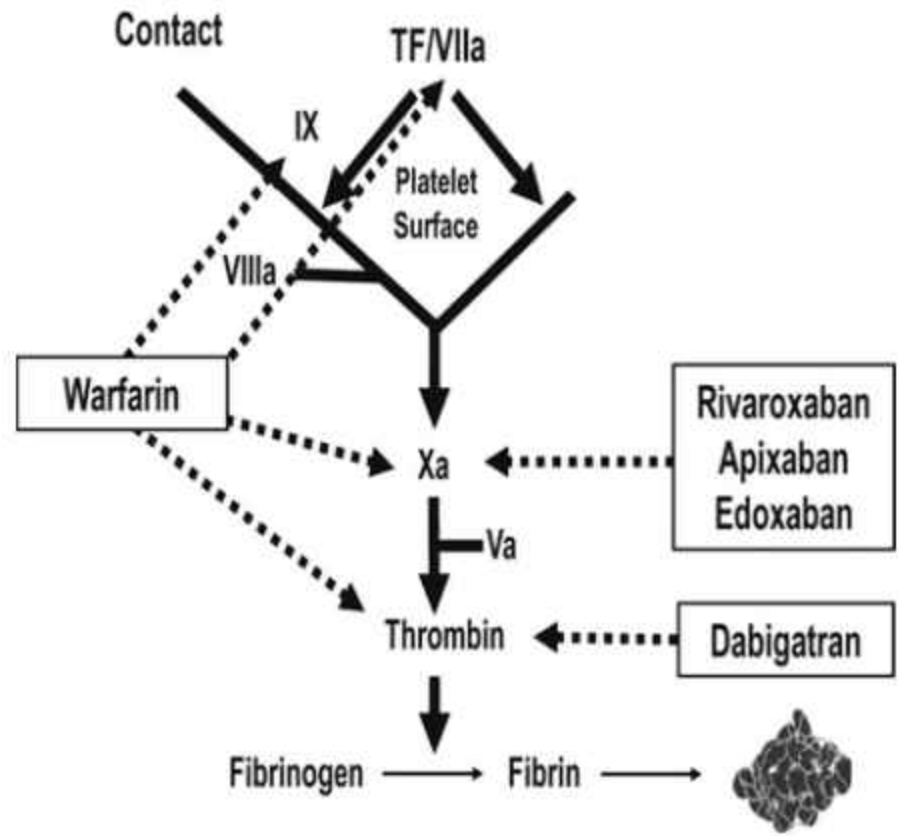
Types of Oral Anticoagulant

Vitamin K Antagonists (VKAs)

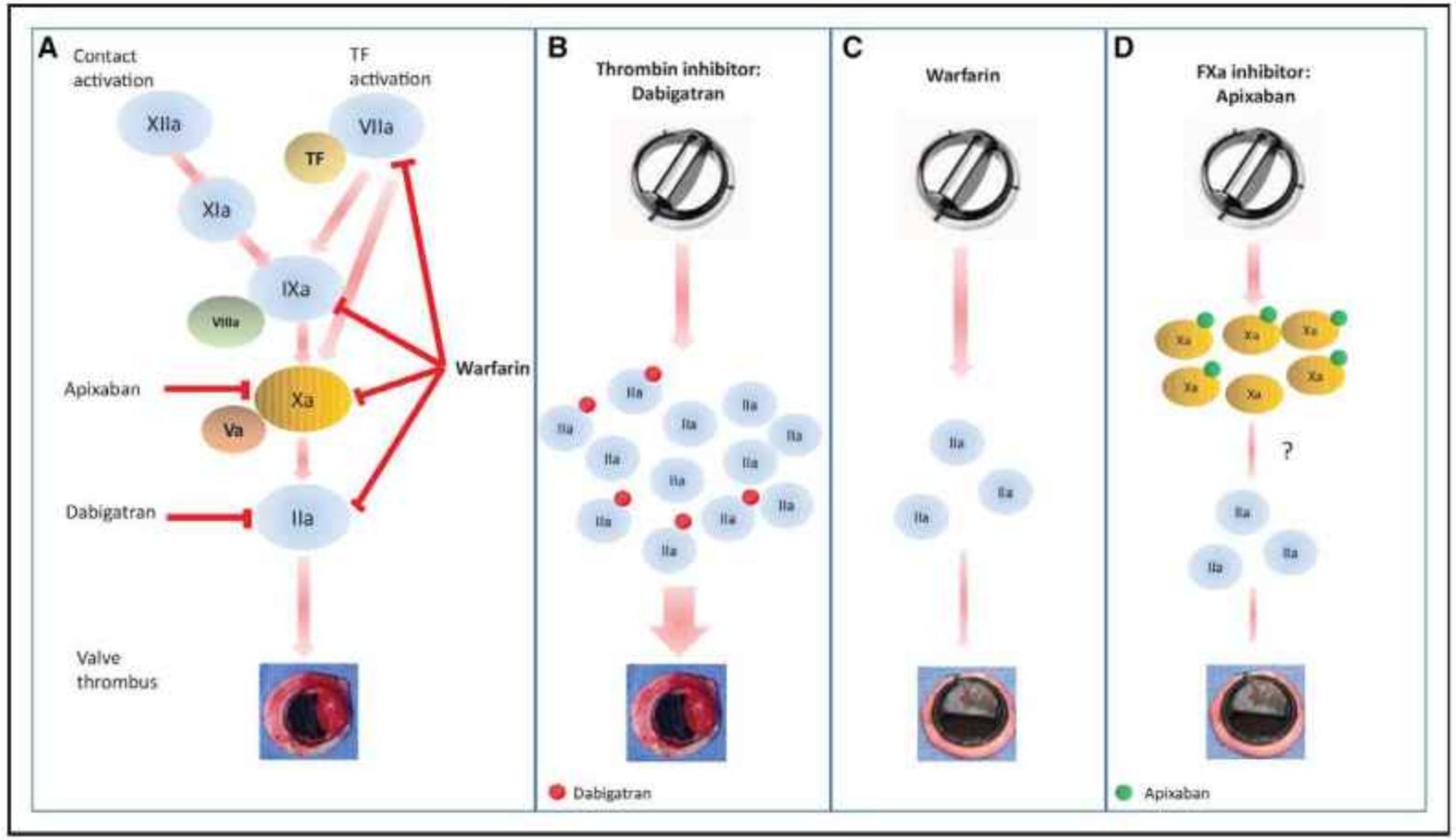
- Warfarin

Direct Oral Anticoagulants (DOACs)

- Rivaroxaban
- Apixaban
- Edoxaban
- Dabigatran



Vitamin K Antagonists (VKAs) vs Direct Oral Anticoagulants (DOACs)



Anticoagulation Therapy: Warfarin

Mechanism of Action

Inhibits vitamin K-dependent synthesis of clotting factors II, VII, IX, and X

Monitoring

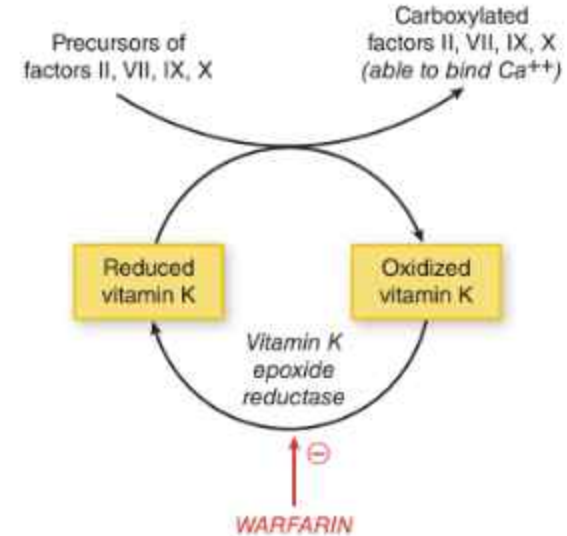
Requires regular INR checks to maintain therapeutic range

Challenges

Narrow therapeutic window, drug-food interactions, bleeding risk

Advantages

Effective, oral administration, reversible with vitamin K



Parameter	Description
Absorption	Almost completely absorbed in the gastrointestinal tract; bioavailability nearly 100%.
Onset of Action	24–72 hours (maximum effect often observed within 3–5 days).
Distribution	Volume of distribution: ~0.14 L/kg; highly bound to plasma albumin (>97%).
Metabolism	Metabolized in the liver via cytochrome P450 enzymes (CYP2C9, CYP3A4, CYP1A2, CYP2C19).
Elimination	Excreted primarily in urine (90%) and minimally in feces.
Half-Life	Average 36–42 hours (can vary between 20–60 hours depending on the individual).
Peak Concentration	Reached within 1–2 hours after oral administration.
Pharmacodynamics	Inhibits vitamin K epoxide reductase, interfering with the synthesis of clotting factors (II, VII, IX, X).
Renal Clearance	Minimal (<5% excreted unchanged via kidneys).
Drug Interactions	Affected by drugs that induce or inhibit CYP450 enzymes, and by foods rich in vitamin K.

Warfarin Challenges

Factors that may affect a patient's warfarin requirements[1,2,3]

Factor		Potential INR effect	Mechanism
Diet	Decreased PO intake	↑	Decreased dietary intake of or increased flushing of vitamin K from GI tract
	Increased PO intake	↓	Increased dietary intake of vitamin K
	Starting tube feeds	↓	May result in warfarin binding to protein in formula, warfarin binding to the tubing or may be due to vitamin K content of tube feed formulation.
	Stopping tube feeds	↑	May result in increased INR if the warfarin dose has been escalated to overcome binding
	TPN or PPN	↑↓	Varies depending on vitamin K content of TPN/PPN
	Low albumin*	↑	Warfarin is highly protein bound (Low albumin = more free warfarin)
Broad spectrum antibiotics		↑	Potentially reduces vitamin K-producing gut flora
GI	Constipation	↓	Decreased elimination of gut vitamin K
	Diarrhea	↑	Increased elimination of gut vitamin K
Disease	Decompensated CHF	↑	Concomitant congestive hepatopathy decreases warfarin metabolism
	Infection	↑	Disruption of hemostasis/increased catabolism; reduced levels of clotting factors
	Malignancy	↑	Potential interactions with chemotherapy agents

Inhibitors of warfarin metabolism (may require less warfarin)

Amiodarone	Fibrates	Phenytoin
Azole antifungals	H2RAs	PPIs
Bactrim	Isoniazid	SSRIs
Cephalosporins	Macrolides	Statins
Chemotherapy	Metronidazole	Steroids
Diltiazem	Protease inhibitors	Thyroid meds
Doxycycline	Quinolones	

Inducers of warfarin metabolism (may require more warfarin)	Increased bleeding risk
Azathioprine	Aspirin
Barbiturates	Clopidogrel
Carbamazepine	Fondaparinux
Nafcillin	NSAIDs
Phenytoin	Prasugrel
Primidone	Ticagrelor
Rifamycins	UFH/LMWHs

Perioperative Period (Stopping & Resuming Anticoagulation)

Preoperative Management:

- Stop Warfarin: Discontinue 5-6 days before surgery.
- Monitor INR: Ensure INR drops below 1.5 before surgery.
- Start UFH: Begin UFH infusion when INR <2.0 (optional bolus of 5,000 units, followed by 12-15 units/kg/hour). Adjust to target aPTT (1.5-2.5× control).
- Stop UFH: Discontinue infusion 4-6 hours before the procedure.

Postoperative Management:

- Resume UFH: Restart infusion 12-24 hours after surgery, balancing bleeding risk.
- Restart Warfarin: Begin warfarin the same day at the previous dose.
- Overlap Therapy: Continue UFH until INR reaches therapeutic range (2.0-3.0 or 2.5-3.5 for high-risk valves) for 24-48 hours.
- Stop UFH: Discontinue UFH once INR is stable within the therapeutic range.

Table 1 Recommended preoperative withholding times of oral antiplatelet and anticoagulant drugs

Drug	Half-life	Time to withhold prior to		Time to restart after	
		Minor surgery	Major Surgery	Minor surgery	Major surgery
Warfarin	20–60 h	3–5 days*	3–5 days	24 h, overlapping therapy with heparin	48–72 h; overlapping therapy with heparin
Phenprocoumon	70–130 h	5–7 days*	5–7 days	24 h, overlapping therapy with heparin	48–72 h; overlapping therapy with heparin
Apixaban	8–15 h	24 h**	48 h**	24 h	24–48 h
Rivaroxaban	5–9 h (Elderly: 11–13 h)	24 h**	48 h**	24 h	24–48 h
Edoxaban	10–14 h	24 h**	48 h**	24 h	24–48 h
Betrixaban	19–27 h	≥4 days	≥4 days	24 h	24–48 h
Dabigatran	12–17 h	CrCl >50 ml: 24 h CrCl <50 ml: 72 h	CrCl >50 ml: 72 h CrCl <50 ml: 120 h	24 h	24–48 h
Aspirin	7–10 days	usually continued	usually continued	usually continued	usually continued
Clopidgrel	7–10 days	5–7 days	5–7 days	24 h	24–48 h
Prasugrel	7–10 days	5–7 days	5–7 days	24 h	24–48 h
Ticagrelor	5–7 days	3–5 days	3–5 days	24 h	24–48 h

*In some cases, continued drug administration is feasible

**In case of impaired renal function, withholding interval should be prolonged and/or drug level should be evaluated by laboratory tests

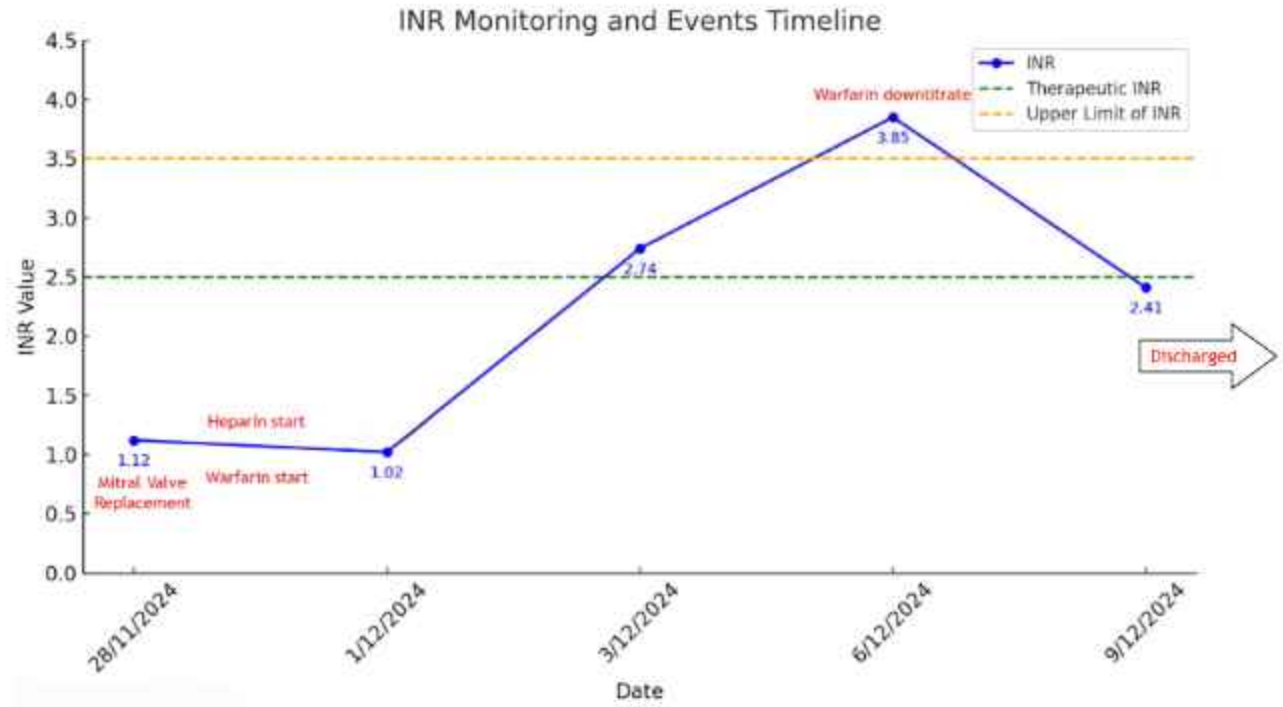
Abbreviations: *CrCl*, creatinine clearance

Warfarin Target & Monitoring

Table 1 **Indications, goals and duration of warfarin therapy** [1]

Indication	Target INR (range)	Duration of therapy
Deep vein thrombosis of the leg or pulmonary embolism	2.5 (2.0–3.0)	At least 3 months
Atrial fibrillation or flutter		
Intermediate to high risk of stroke	2.5 (2.0–3.0)	Indefinite
Elective cardioversion	2.5 (2.0–3.0)	3 weeks before scheduled cardioversion and for 4 weeks after successful cardioconversion
Mitral stenosis	2.5 (2.0–3.0)	Indefinite
After stent placement and high risk of stroke	2.5 (2.0–3.0)	Bare-metal stent (1 month) and drug-eluting stent (3–6 months) as triple therapy with clopidogrel and aspirin After initial triple therapy, continue warfarin and a single antiplatelet drug until 12 months after stent placement After 12 months, use warfarin alone
Valvular heart disease		
Rheumatic mitral valve disease	2.5 (2.0–3.0)	Long term
Mechanical prosthetic heart valves	Bileaflet or tilting-disk valves: 2.5 (2.0–3.0) in the aortic position and 3.0 (2.5–3.5) in the mitral position	Long term Recommended to use aspirin in addition, 50–100 mg daily, if low bleeding risk
Bioprosthetic valves in the mitral position	2.5 (2.0–3.0)	3 months after insertion

Dosing Adjustments	Goal INR 2.5-3.5
– Consider a one-time dose increase of 1½ - 2 times daily maintenance dose – If adjustment to maintenance dose needed, increase dose by 10-20%* – Repeat INR in 1 week	INR < 2.0
– Consider a one-time dose increase of 1½ times daily maintenance dose – If adjustment to maintenance dose needed, increase dose by 5-15%* – Repeat INR in 2 weeks	INR 2.0-2.2
– No dosage adjustment may be necessary if the last two INRs were in range** – Repeat INR within 8 weeks – Consider a one-time dose increase of 1½ times daily maintenance dose – If adjustment to maintenance dose needed, increase dose by 5-10%* – Repeat INR in 2 weeks	INR 2.3 – 2.4
Desired range **Repeat INR within 8 weeks**	INR 2.5 – 3.5
– No dosage adjustment may be necessary if the last two INRs were in range** – Repeat INR within 8 weeks – Consider a one-time dose decrease of ½ of daily maintenance dose – If adjustment to maintenance dose needed, decrease dose by 5-10%* – Repeat INR in 2 weeks	INR 3.6– 3.7
– Consider holding ½ to 1 dose – If adjustment to maintenance dose needed, decrease dose by 5-10%* – Repeat INR in 2 weeks	INR 3.8 – 4.4
– Hold 1-2 doses – If adjustment to maintenance dose needed, decrease dose by 5-15%* – Repeat INR within 1 week	INR 4.5 – 6.0
– Hold 1-2 doses – If adjustment to maintenance dose needed, decrease dose by 10-20%* – Repeat INR within 5 days – If outpatient, consult clinic supervisor	INR 6.1 - 8.9
– Hold until INR < upper limit of therapeutic range – Consider use of vitamin K PO 2.5mg – 5mg – Repeat INR in 1-2 days – If outpatient, consult clinic medical director – When safe, resume warfarin at lowered dose (10-20%)	INR > 9.0



Summary

- Postoperative management in patients undergoing mitral valve replacement with a mechanical valve requires an optimal anticoagulation strategy.
- This case report highlights a 63-year-old female with severe mitral stenosis who underwent successful mechanical mitral valve replacement. Postoperative care emphasized anticoagulation with heparin bridging and warfarin initiation on day two, monitored to achieve therapeutic INR. The patient showed good recovery, was discharged in stable condition, and planned for routine follow-up. This underscores the importance of evidence-based anticoagulation and patient education for minimizing complications and ensuring long-term outcomes.

Thank You!

Suggested protocol for initiating warfarin therapy

Days of warfarin treatment	INR <1.5	INR 1.5 to 1.9	INR 2.0 to 3.0	INR >3.0
Suggested initial dose for days 1 and 2				
Normal adult	5 mg*	n/a	n/a	n/a
Frail adult, malnourished, elderly, liver disease	2.5 mg*	n/a	n/a	n/a
Dosing for day 3 and beyond				
Day 3	5 to 10 mg	2.5 to 5 mg	0 to 2.5 mg	No dose
Day 4	10 mg	5 to 7.5 mg	0 to 5 mg	No dose
Day 5	10 mg	7.5 to 10 mg	0 to 5 mg	No dose
Day 6	7.5 to 12.5 mg	5 to 10 mg	0 to 7.5 mg	No dose

TABLE 1

Which patients on warfarin should receive heparin bridging before surgery?

High risk for thromboembolism: bridging advised

- Known hypercoagulable state as documented by a thromboembolic event and one of the following:
  - Protein C deficiency
  - Protein S deficiency
  - Antithrombin III deficiency
  - Homozygous factor V Leiden mutation
  - Antiphospholipid-antibody syndrome
- Hypercoagulable state suggested by recurrent (two or more) arterial or idiopathic venous thromboembolic events (not including primary atherosclerotic events, such as stroke or myocardial infarction due to intrinsic cerebrovascular or coronary disease)
- Venous or arterial thromboembolism within the preceding 1–3 months
- Rheumatic atrial fibrillation
- Acute intracardiac thrombus visualized by echocardiogram
- Atrial fibrillation plus mechanical heart valve in any position
- Older mechanical valve model (single-disk or ball-in-cage) in mitral position
- Recently placed mechanical valve (< 3 months)
- Atrial fibrillation with history of cardioembolism

Intermediate risk for thromboembolism: bridging on a case-by-case basis

- Cerebrovascular disease with multiple (two or more) strokes or transient ischemic attacks without risk factors for cardiac embolism
- Newer mechanical valve model (eg, St. Jude) in mitral position
- Older mechanical valve model in aortic position
- Atrial fibrillation without a history of cardiac embolism but with multiple risks for cardiac embolism (eg, ejection fraction < 40%, diabetes, hypertension, nonrheumatic valvular heart disease, transmural myocardial infarction within preceding month)
- Venous thromboembolism > 3–6 months ago*

Low risk for thromboembolism: bridging not advised

- One remote venous thromboembolism (> 6 months ago)*
- Intrinsic cerebrovascular disease (such as carotid atherosclerosis) without recurrent strokes or transient ischemic attacks
- Atrial fibrillation without multiple risks for cardiac embolism
- Newer-model prosthetic valve in aortic position

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*For patients with a history of venous thromboembolism undergoing major surgery, consideration can be given to postoperative bridging therapy only (without preoperative bridging)

Box 2: Suggested risk stratification scheme for perioperative thromboembolism[3]

Risk category (% annual risk of thromboembolism)	Atrial fibrillation	Mechanical heart valve	Venous thromboembolism (VTE)
High (> 10%)	$CHADS_2$ score[1] of 5 or 6; recent (within 3 mo) stroke or transient ischemic attack (TIA); rheumatic valvular heart disease	Any mitral valve prosthesis; any caged-ball or tilting-disk aortic valve prosthesis; recent (within 6 mo) stroke or TIA	Recent (within 3 mo) VTE; severe thrombophilia (e.g., deficiency of protein C, protein S or antithrombin; antiphospholipid antibodies; multiple abnormalities)
Moderate (5%–10%)	$CHADS_2$ score[1] of 3 or 4	Bi-leaflet aortic valve prosthesis and ≥ 1 risk factor (atrial fibrillation, prior stroke or TIA, hypertension, diabetes, congestive heart failure, age > 75 yr)	VTE within past 3–12 mo; nonsevere thrombophilia (heterozygous factor V Leiden or prothrombin gene mutation); recurrent VTE; active cancer (treated within 6 mo or palliative)
Low (< 5%)	$CHADS_2$ score[1] of 0 to 2 (no prior stroke or TIA)	Bi-leaflet aortic valve prosthesis without atrial fibrillation and no other risk factors for stroke	VTE > 12 mo previous

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