NEUROCARDIOLOGY: CURRENT PRACTICES IN THE STROKE MANAGEMENT

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DISCLOSURES

- None

CURRENT PRACTICES IN NEUROCARDIOLOGY

Outline

- Atrial fibrillation (AF) as a stroke risk factor
  - Available devices to detect AF after stroke
  - Left atrial appendage (LAA) closure for stroke prevention
- Patent foramen ovale (PFO) as a stroke risk factor
  - Benefit of PFO closure
- Heart-brain collaboration

CLINICAL CASE #1

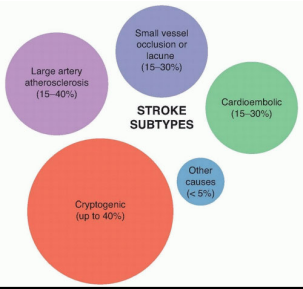
77-years-old man with HTN, DM, CAD, smoker, OSA, presented with aphasia and right hemiparesis, found to have left MCA territory embolic infarct. CTA does not show significant vessel stenosis. TTE showed normal ejection fraction, moderate dilatation of left atrium and no significant valvular abnormality. ECG shows sinus rhythm

What is the stroke mechanism?

What are the next steps?

STROKE MECHANISMS

TOAST-**T**rial of **O**rg 10172 in **A**cute **S**troke **T**reatment



CRYPTOGENIC STROKE AND ESUS

"Cerebral infarction for which no probable cause is identified after adequate diagnostic evaluation"

Cryptogenic stroke according to TOAST:

1) Incomplete workup
2) More than one potential cause
3) **No determined etiology after complete investigation**

Embolic stroke of undetermined source (ESUS) -international working group 2014

"Non-lacunar infarct in the absence of: extracranial or intracranial atherosclerosis causing>50% luminal stenosis in the artery supplying the ischemic region, major cardioembolic sources permanent or paroxysmal atrial fibrillation (AF), sustained atrial flutter, intracardiac thrombus, prosthetic cardiac valve, atrial myxoma or other cardiac tumors, mitral stenosis, myocardial infarction within the past 4 weeks, left ventricular (LV) **ejection fraction <30%,** valvular vegetation's or infective endocarditis, and no dissection, arteritis, migraine/vasospasm, drugs"

CARDIAC CAUSES OF THE STROKE

Sources with high primary risk of ischemic stroke

- Left atrial thrombus
- Left ventricular thrombus
- Atrial fibrillation
- Paroxysmal atrial fibrillation
- Sick sinus syndrome
- Sustained atrial flutter
- Recent myocardial infarction (within 1 month)
- Mitral stenosis or rheumatic valve disease
- Bioprosthetic and mechanical heart valves
- Chronic myocardial infarction together with low ejection fraction <28%
- Dilated cardiomyopathy
- Non-bacterial thrombotic endocarditis
- Infective endocarditis
- Papillary fibroelastoma
- Left atrial myxoma
- Patent foramen ovale and concurrent systemic embolism

Sources with low or uncertain primary risk of ischemic stroke

- Mitral annular calcification
- Patent foramen ovale
- Atrial septal aneurysm
- Left ventricular aneurysm without thrombus
- Isolated left atrial smoke (no mitral stenosis or atrial fibrillation)
- Complex atheroma in the ascending aorta or proximal arch
- Symptomatic congestive heart failure with ejection fraction <30%
- Wall motion abnormalities (hypokinesia, akinesia, dyskinesia)
- Hypertrophic cardiomyopathy
- Left ventricular hypertrophy
- Left ventricular hypertrabeculation/non-compaction
- Other rare sources (atrial or ventricular septal defect, preexcitation syndromes, left atrial dilation)

ATRIAL FIBRILLATION (AF)

- Framingham Heart Study: in 37% after the age of 55 years
- Paroxysmal >2/3, 5-10%/y progress to persistent

TABLE 1. Stroke risk stratified by CHA_2DS_2-VASc score[47]

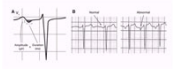
$CHADS_2$		CHA_2DS_2-VASc		CHA_2DS_2-VASc score	Adjusted stroke rate (%/year)
Risk factor	Score	Risk factor	Score		
CHF	1	CHF/LV dysfunction	1	0	0
HT	1	HT	1	1	1.3
Age ≥75 years	1	Age ≥75 years	2	2	2.2
DM	1	DM	1	3	3.2
Prior stroke/TIA	2	Stroke/TIA/TE	2	4	4.0
		Vascular disease (prior MI, PAD, or aortic plaque)	1	5	6.7
		Age 65-74 years	1	6	9.8
		Sex (female)	1	7	9.6
				8	6.7
Maximum score	**6**	**Maximum score**	**9**	9	15.2

Abbreviations: CHF = congestive heart failure; DM = diabetes mellitus; HT = hypertension; LV = left ventricle; MI = myocardial infarction; PAD = peripheral arterial disease; TE = thromboembolism; TIA = transient ischaemic attack

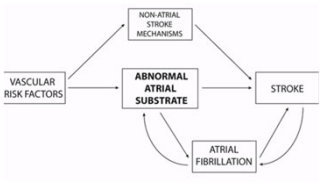
AF risk factors:
- Older age
- Male
- Obesity
- CAD
- HTN
- Smoking
- DM
- OSA
- Family
- h/o AF in a first-degree relative

ATRIAL CARDIOPATHY

Fibrotic changes in the atrium might be a precursor of afib



Atrial cardiopathy:
- PTFV1 >5000mVs on 12-lead ECG
- Serum NT-proBNP >250pg/mL
- Left atrial enlargement



One third of patient with both AF and stroke do not manifest AF until after the stroke, despite many month of monitoring prior to stroke

CLINICAL CASE #1

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What is the stroke mechanism?

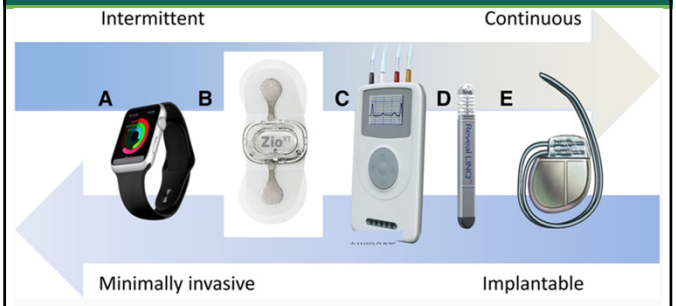
Cryptogenic-ESUS

What are the next steps?

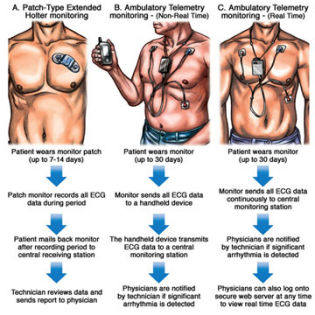
Cardiac monitor

-Which device and how long?

SCREENING FOR AF-CLOSING THE LOOP



EXTERNAL AMBULATORY ECG MONITORING



ASSERT: patients with pacemaker/ defibrillator monitored for AF (>6min atrial rate >190) for 3m

- AF detected in 10%
- Increased risk of stroke over 2.5y, HR 2.49 CI1.28 to 4.85, P=0.007

EMBRACE-24-h Holter monitor vs. 30-day outpatient event monitor

- 30sec AF detected in 16.1% with 30d monitor vs 3.2% with 24h holter P < 0.001

REVEAL LINQ ICM

CRYSTAL AF – implantable long term monitor vs standard evaluation, 2min of AF

- 8.9% vs 1.4% AF detection at 6m in patients with REVEAL; HR=6.4 (95% CI, 1.9–21.7), P<0.001
- **AF detected in 9% at 6m, 12% at 1y and 30% at 3y**

APPLE HEART STUDY

- 419,297 US adults, 25000 ≥ 65
- 2160 (0.5%) notified for irregular heart rhythm; rate higher in ≥ 65yo (3.2%)
- 450/2160 (21%) returned wearable ECG patch
- AF confirmed in 153/450 (34%)

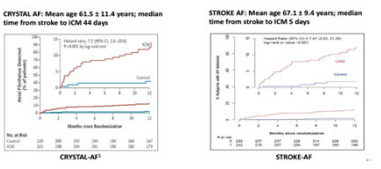
Low AF rate concerning for poor accuracy;
Unnecessary diagnostic test and treatment in patients who receive notification

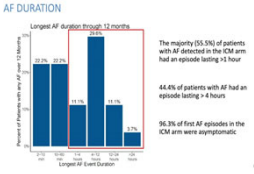
PREVALENCE OF AF IN NON EMBOLIC STROKE

- Patients with ischemic stroke attributed to small or large vessel disease within 10d from stroke
- Age >60, or age 50-59y with one additional risk factors: congestive HF, HTN, DM, prior stroke within 90d prior MI, PAD, aortic plaque
- Medial CHA2-DS2-VASc score 5

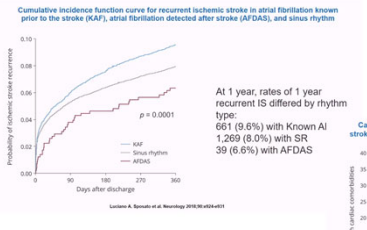
- Median time to first detected AF was 99d
- Number needed to monitor for 1 AF case detected was 8 in ICM arm vs 56

COMPARISON OF AF DETECTION IN TWO POPULATIONS
CRYSTAL AF (CRYPTOGENIC) VS. STROKE AF (SVO/LAA)
INCIDENCE RATES OF AF THROUGH 12 MONTHS

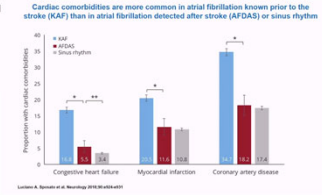




AF BEFORE OR AFTER THE STROKE



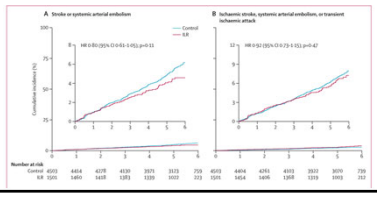
At 1 year, rates of 1 year recurrent IS differed by rhythm type:
661 (9.6%) with Known AI
1,269 (8.0%) with SR
39 (6.6%) with AFDAS



ARE ALL AF WORTH SCREENING FOR

Loop study – Denmark

- 70-90yo with HTN or DM or HF or previous stroke
- ILR vs usual care; median CHA2DS2 VASc score 4
- ~17% with h/o stroke in both arms
- AF found in 31.8% in ILR group and vs 12·2% in control (HR 3·17, CI 2·81–3·59, p<0·0001)



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30d monitor – no AF

Implantable cardiac monitor- 7min of AF

What would you do next?

AF TREATMENT

C Considerations in Management of AF

Rate Control during AF
Beta-blockers
Verapamil, diltiazem
Digoxin
AV junction ablation plus pacemaker (in selected patients)

→

Stroke Prevention
Anticoagulation
Occlusion or resection of atrial appendage (in selected patients)

→

Treatment of Risk Factors for AF
Hypertension
Hyperlipidemia
Diabetes mellitus
Obesity
Sleep apnea
Excessive alcohol use

→

Long-Term Strategy for Reducing Symptoms
Maintain Sinus Rhythm
Antiarrhythmic medications
Catheter ablation
Surgical maze
or
Manage Continued AF

No cardioversion unless AF is <48h old or TEE is negative for thrombus

ANTICOAGULATION FOR AF

Warfarin or Direct Oral Anticoagulants
62% risk reduction compared to placebo

DOAC vs Warfarin

- Risk of stroke or systemic emboli 11% lower with DOAC vs warfarin
- Lower risk of ICH with DOACs vs Warfarin

Use Warfarin if: mechanical valve, valvular AF, APLS, LV thrombus

DOACS FOR AF

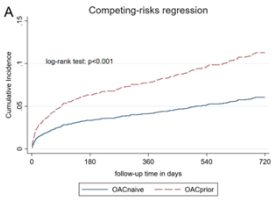
Table 1 The efficacy, safety, and special considerations for direct oral anticoagulants (DOAC)

Study (DOAC)	Dosing	Mean age (+/− SD /median (IQR)	Mean f/u yrs	Mean TTR	Mean $CHADS_2$ (+/− SD)	Ischemic stroke, /100 patient-years HR vs. warf (95% CI)	Intracranial hemorrhage /100 patient-years HR vs. warf (95% CI)	Permanent Discontinuation	
RE-LY (dabigatran) $n = 18,113$	150 mg b.i.d	71.5 ± 8.8	2	64%	2.1 ± 1.1	0.92 vs. 1.2% RR 0.76 (0.60–0.98) $p = 0.03$	0.30 vs. 0.74% RR 0.40 (0.27–0.60) $P < 0.001$	Dabigatran Warfarin	21.2% 16.6%
ARISTOTLE (apixaban) $n = 18,201$	5 mg b.i.d	70 (63–76)	1.8	62%	2.1 ± 1.1	0.97 vs. 1.05% HR 0.92 (0.74–1.13) $p = 0.42$	0.33 vs. 0.80% HR 0.42 (0.30–0.58), $p < 0.001$	Apixaban Warfarin	25.3% 27.5%
ENGAGE-AF (edoxaban) $n = 21,105$	60 mg/day	72 (64–78)	2.8	66%	2.8 ± 1.0	1.25 vs. 1.25% HR 1 (0.83–1.19) $p = 0.97$	0.39 vs. 0.85% HR 0.47 (0.34–0.63), $P < 0.001$	Edoxaban Warfarin	34.4% 34.5%
ROCKET-AF (rivaroxaban) $n = 14,264$	20 mg/day	73 (65–78)	1.94	55%	3.5 ± 1	1.34 vs. 1.42% HR 0.94 (0.75–1.17) $p < 0.581$	0.5 vs. 0.7%, HR 0.67 (0.47–0.93), $p = 0.02$	Rivaroxaban Warfarin	23.7% 22.2%

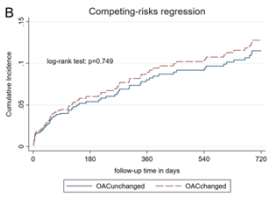
None of the trials enrolled patients with h/o bleeding or at risk for high bleeding

STROKE WHILE TAKING ANTICOAGULATION

Patients who have stroke on oral anticoagulation are at higher risk of recurrent stroke?



Changing the type of oral anticoagulant is not associated with reduced risk of stroke



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30d monitor – no AF

Implantable cardiac monitor- 7min of AF

Started Apixaban

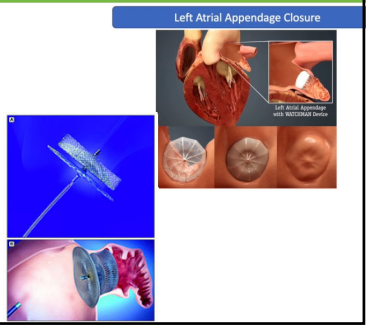
15 months later patient developed intracerebral hemorrhage

What would you do next?

ALTERNATIVE TO ANTICOAGULATION

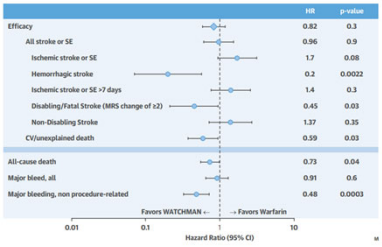
Increased risk of bleeding

- Thrombocytopenia
- Recurrent bleeding
- Prior severe bleeding
- High risk of falling
- Strong indication for combined use of dual antiplatelet and anticoagulant
- Poor compliance



LAA CLOSURE VS WARFARIN

LLA closure vs Warfarin- PROTECT AF & PREVAIL

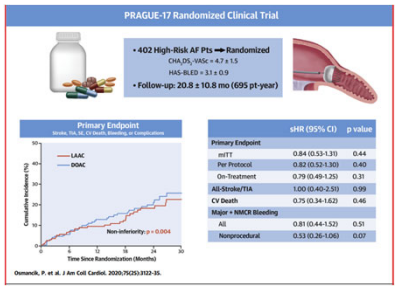


Anticoagulation Regimen

- Implant to 6 weeks
  - Warfarin
  - Aspirin
- 6 weeks to 6 months
  - Clopidogrel
  - Aspirin
- After 6 months
  - Aspirin

LAA CLOSURE VS DOAC

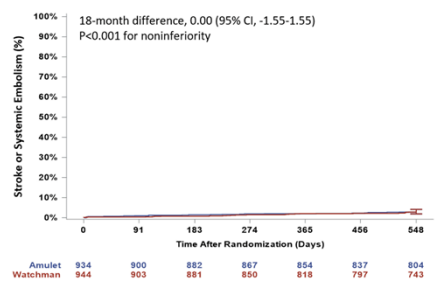
PRAGUE 17 trial



Non valvular AF +

- h/o bleeding requiring intervention or hospitalization or
- h/o cardioembolic event while taking oral anticoagulation or

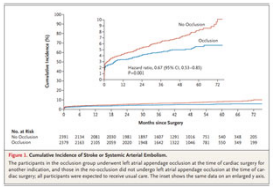
WATCHMAN AND AMULET DEVICES



LAA CLOSURE FOR PRIMARY PREVENTION

LAAOS III trial

- Included: AF and CHA2 DS2 -VASc ≥ 2 undergoing cardiac surgery for another reason
- Primary outcome: stroke or systemic emboli
- >4600 included
- Mean CHA2 DS2 -VASc score of 4.2
- 76.8% continued anticoagulation



Primary outcome in 4.8% in occlusion group vs 7.0% (HR 0.67, CI0.53 to 0.85; P=0.001)

PATENT FORAMEN OVALE (PFO)

CLINICAL CASE #2

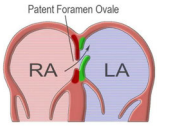
37-year-old woman with no medical history, on OCP, was admitted with mild right hemiparesis and aphasia. MRI showed scattered left MCA territory cortical infarcts. CTA head and neck, TTE, UDS, blood work is unremarkable. TEE showed moderate size PFO with ~25 bubbles crossing from right to left atrium. She also has atrial septal aneurysm. Hypercoagulable panel was negative and 30day cardiac monitor did not reveal atrial fibrillation or other significant arrhythmia. Leg doppler did not show DVT

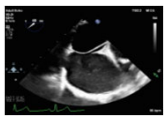
A) Antiplatelet until PFO closure
B) Anticoagulation DOAC until PFO closure
C) Antiplatelet only, no need for PFO closure
D) Anticoagulation only, no need for PFO closure
E) PFO closure and lifelong anticoagulation

PFO-BACK DOOR TO THE BRAIN

Interatrial slit-like channel or tunnel with a mean diameter ~5mm

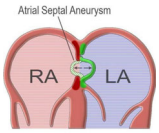
- PFO is a one of the most common congenital cardiac findings
- ~25% in general population
- Linked to stroke, systemic and coronary embolization, OSA, migraine with aura
- PFO is present in ~50% of cryptogenic stroke patients





STROKE MECHANISMS IN PFO

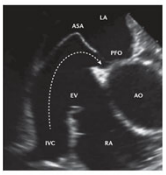
- **Paradoxical embolus**
- Direct in-situ thrombus formation
- Arrhythmia



Atrial septal "aneurysm" (ASA) 0.2 to 10%

- Focal outpouching of the hypermobile interatrial septum

-Increases stroke risk 6-fold when present with PFO



DIAGNOSTIC MODALITIES FOR PFO DETECTION

	PFO shunt	Advantage	Disadvantage
TTE	Sensitivity 50-80% R to L shunt within 3 cardiac cycles *Trace <5 bubbles* *Moderate: 6–20 particles* *Severe: >20 particles*	-Easily available -Allows for a better Valsalva maneuver with agitated saline contrast -Low cost	-Limited anatomic assessment of intraatrial septum -Limited by technical factors -Not reliable for small shunts
TEE	Sensitivity ~90-100% R to L shunt within 3 cardiac cycles *Trace <5 bubbles* *Moderate: 6–20 particles* *Severe: >20 particles*	-Gold standard for visualization of the foramen ovale and associated anatomy -Surgical planning **TCD can detect small shunt missed by TEE due to better Valvalva**	-Invasive -Requires anesthesia -Local pharyngeal trauma, patient discomfort -Requires dedicated physician operator -Costly
TCD	Mild–moderate Spencer grade I, II Moderate–severe Spencer grade III–V	Highly sensitive for identifying -R to L shunt -Determining shunt magnitude -Predicting post device residual shunting	-Cannot determine the location of the shunt or anatomy -Baseline positivity in patients with no anatomic shunt

IS PFO INCIDENTAL OR RELATED TO THE STROKE

RoPE score

Characteristic	Points	RoPE score
No history of hypertension	1	
No history of diabetes	1	
No history of stroke or TIA	1	
Nonsmoker	1	
Cortical infarct on imaging	1	
Age, y		
18-29	5	
30-39	4	
40-49	3	
50-59	2	
60-69	1	
≥70	0	
Total score (sum of individual points)		
Maximum score (a patient <30 y with no hypertension, no diabetes, no history of stroke or TIA, nonsmoker, and cortical infarct)		10
Minimum score (a patient ≥70 y with hypertension, diabetes, prior stroke, current smoker, and no cortical infarct)		0

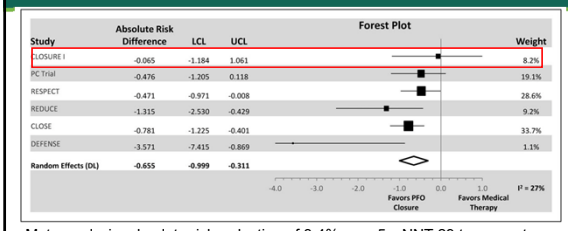
ROPE SCORE

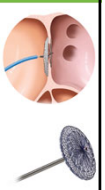
Patients more likely to have stroke related to PFO have lower recurrence risk

	CS patients with PFO (n = 1,324)	
RoPE score	No. of CS patients with PFO*	Estimated 2-y stroke/TIA recurrence rate (Kaplan-Meier), % (95% CI)
0-3	108	20 (12-28)
4	148	12 (6-18)
5	186	7 (3-11)
6	236	8 (4-12)
7	263	6 (2-10)
8	233	6 (2-10)
9-10	150	2 (0-4)

Variables not included in RoPE study: hypercoagulable state, OCP, DVT/PE, prolonged travel/immobility, migraine, Valsalva at stroke onset, size of PFO/shunt or presence of ASA

PFO CLOSURE VS MEDICAL THERAPY





Meta-analysis: absolute risk reduction of 3.4% over 5y; NNT 29 to prevent one stroke

-6 fold increase in AF in closure arm; ~3% major periprocedural complications

- ASA - NNT 13 over 5y
- Large shunt size - NNT 18

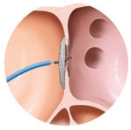
PFO CLOSURE DEVICES APPROVED IN USA

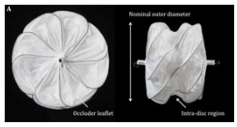
The St. Jude Amplatzer PFO Occluder

Two asymmetric Nitinol wire mesh which traverses the PFO

Gore Cardioform Septal Occluder

Two Nitinol discs which span the PFO





SUBGROUPS TO CONSIDER

Age: most trials only included patients <60y

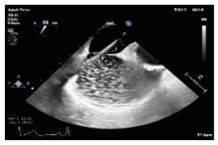
Patients on anticoagulation: benefit of closure in unclear

RESPECT: no benefit of PFO closure among anticoagulated patient (HR 1.32; CI 0.43–4.03; P. 0.63)

Patients with thrombophilia:

-All trials excluded patients with antiphospholipid antibodies

-Testing for intertied thrombophilia was sporadic in trials



Trial	Women on OCPs	RESPECT-LT		REDUCE		CLOSE	
		Device Arm	Medical Arm	Device Arm	Medical Arm	Device Arm	Medical Arm

ANTIPLATELET VS ANTICOAGULATION WITHOUT CLOSURE

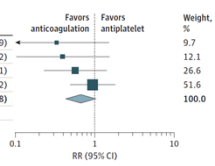
Figure 1. Forest Plots Showing Study-Level Meta-analyses of Randomized Clinical Trials of Strategies to Prevent Recurrent Ischemic Stroke in Patients With Patent Foramen Ovale (PFO)

A Anticoagulation vs antiplatelet therapy

Study or subgroup	Anticoagulation Events	Anticoagulation Total	Antiplatelet Events	Antiplatelet Total	RR (95% CI)	Weight, %
PICSS, 2002	2	42	8	56	0.33 (0.07-1.49)	9.7
CLOSE, 2017	3	187	7	174	0.40 (0.10-1.52)	12.1
NAVIGATE ESUS, 2018	7	259	13	275	0.57 (0.23-1.41)	26.6
RE-SPECT ESUS, 2019	16	319	19	361	0.95 (0.50-1.82)	51.6
Total	**28**	**807**	**47**	**866**	**0.68 (0.42-1.08)**	**100.0**

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 2.68$; $df = 3$; $P = .44$; $I^2 = 0\%$

Test for overall effect: $z = 1.65$; $P = .10$



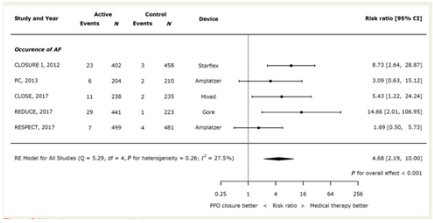
No benefit of anticoagulation compared to antiplatelet therapy for recurrent stroke in patients with PFO

AF AFTER PFO CLOSURE

5-fold increased risk of AF after closure compared to medical therapy (OR 5.3, CI 2.5–11.41, p<0.001)
-Highest risk within first 45d

AF is higher in:

- Older patients
- Residual shunt after closure
- LA enlargement



CLINICAL CASE #2

37-year-old woman with no medical history, on OCP, was admitted with mild right hemiparesis and aphasia. MRI showed scattered left MCA territory cortical infarcts. CTA head and neck, TTE, UDS, blood work is unremarkable. TEE showed moderate size PFO with ~25 bubbles crossing from right to left atrium. She also has atrial septal aneurysm. Hypercoagulable panel negative and 30day cardiac monitor did not reveal atrial fibrillation or other significant arrhythmia. Leg doppler did not show DVT.

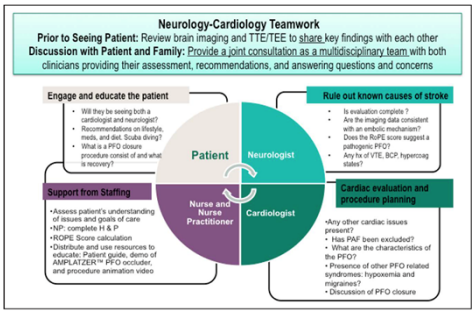
In addition to stopping OCP what else would you recommend?

A) Antiplatelet until PFO closure
B) Anticoagulation with DOAC until PFO closure
C) Antiplatelet only, no need for PFO closure
D) Anticoagulation only, no need for PFO closure
E) PFO closure and lifelong anticoagulation

HEART-BRAIN CLINICS

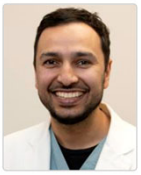
UAB THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

HEART-BRAIN MULTIDISCIPLINARY TEAM



HEART-BRAIN COLLABORATION AT UAB


Ekaterina Bakradze, MD


Mustafa Ahmed, MD

Referrals from across the state

Timely evaluation by interventional cardiology and stroke Neurology

Telemedicine evaluation during COVID pandemic

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PFO

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THANK YOU

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PFO AND MIGRAINE

PFO is twice as common in patients with migraine with aura

Migraine patients tend to have large shunts

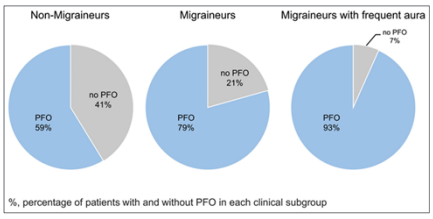

Figure 3. Prevalence of patent foramen ovale (PFO) in patients with cryptogenic stroke.

Nat Rev Dis Primers 2016 Jan 21;2:15086 PMID: 27188965

Brian H West et al. Stroke 2018 May;49(5):1123-1128. PMID: 29636424

MIGRAINE AND PFO

Percutaneous Closure of Patent Foramen Ovale in P

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Jonathan M. Tobis, MD,[a] ,
Brijeshwar Maini, MD,[c] Ph

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Patent Foramen Ovale Closure for Treating Migraine: A Meta-Analysis

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Received 3 November 2021; Revised 24 December 2021; Accepted 3 January 2022; Published 2 February 2022

Academic Editor: Thach N. Nguyen

Background. Observational studies have shown percutaneous patent foramen ovale (PFO) closure to be a safe means of reducing the frequency and duration of migraine. *Objective.* This study evaluated the efficacy and safety of PFO closure in patients with migraine using evidence-based medicine. *Methods.* The Pubmed (MEDLINE), Embase, and Cochrane Library databases were searched for randomized controlled trials (RCTs), cohort studies, and retrospective case series from January 1, 2001, to February 30, 2021. The Jadad scale and R 4.1.0 software were used to assess the quality of the literature and meta-analysis, respectively. *Results.* In total, three randomized controlled trials, one pooled study, and eight retrospective case series including 1,165 participants were included in the meta-analysis. Compared with control intervention in migraine, PFO closure could significantly reduce headache frequency (OR = 1.5698, 95% CI: 1.0465–2.3548, $p = 0.02933$) and monthly migraine attacks and monthly migraine days (OR = 0.2598, 95% CI: 0.0790–0.4398, $p = 0.00481$). Subgroup analysis of patients who all completed PFO surgery showed resolution of migraine headache for migraines with aura (OR = 1.5856, 95% CI: 1.0665–2.3575, $p = 0.0227$). *Conclusions.* Treatment with PFO closure could reduce the frequency of headaches and monthly migraine days and is an efficient treatment for migraine attacks with aura.

ent foramen ovale in
nized controlled trial

ck-Smith[3], Werner J. Becker[4],
k Gawel[5], Hartmut Göbel[6],
Ray[8], Adam Zermansky[10],
hard Meier[11]

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