



# IT'S THE SHUNT

Paradoxical embolic stroke: Common but dangerous

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NEUROVASCULAR COORDINATOR

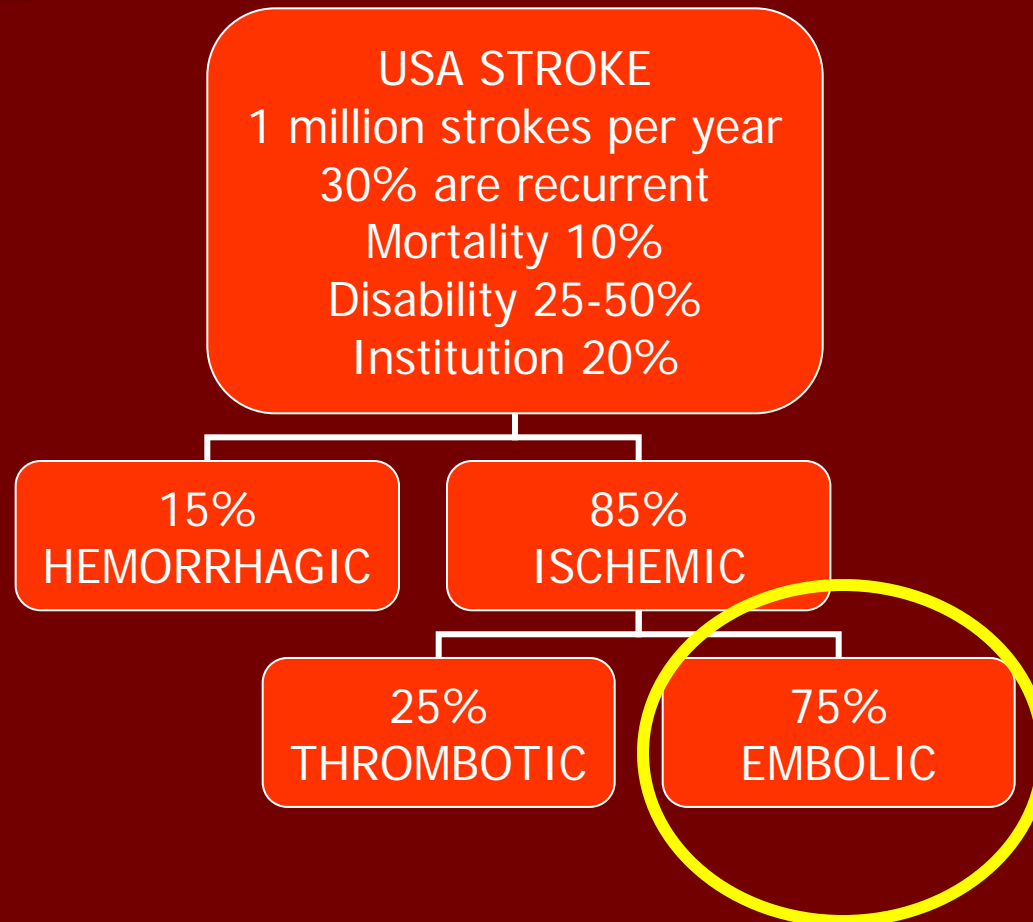
SORENSEN CARDIOVASCULAR GROUP

# DISCLOSURE

NOTHING TO DISCLOSE

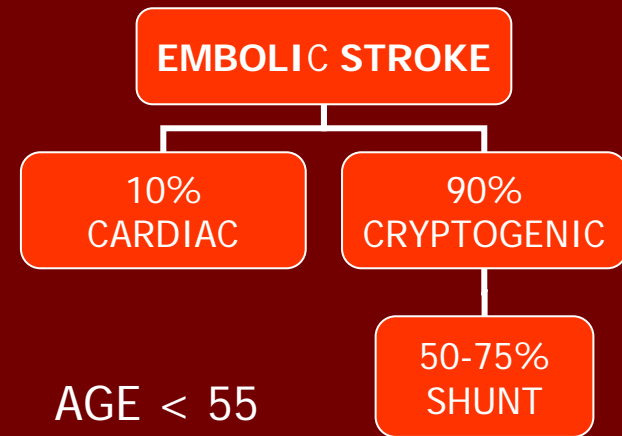
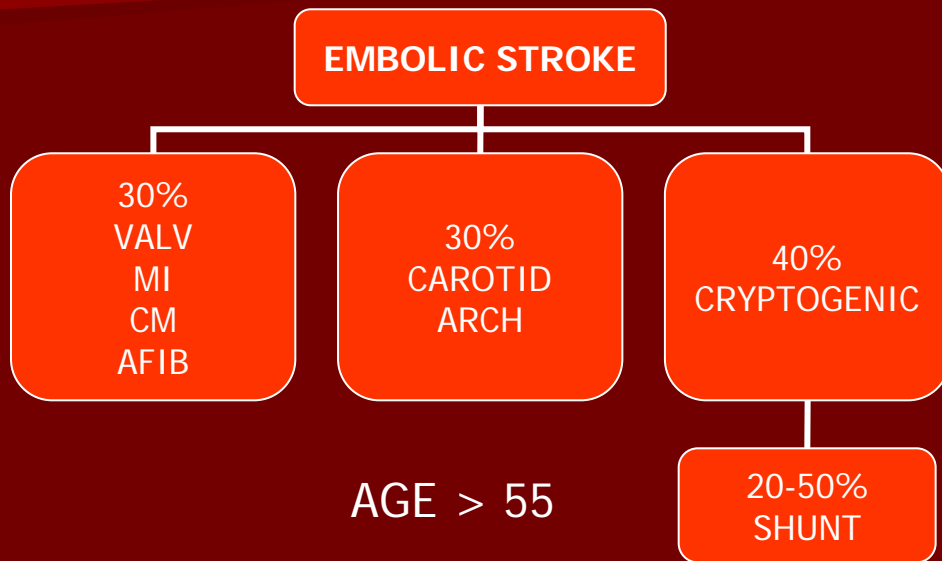
# CAUSES OF STROKE

Understanding the many different causes of stroke



# UNDERSTANDING STROKE CAUSE

Embolic stroke of any cause has the highest disability rate of 50%\*



5-8% of stroke occurs in persons < 55

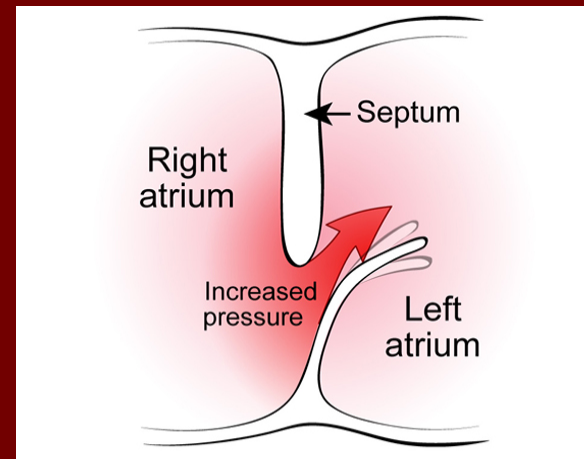
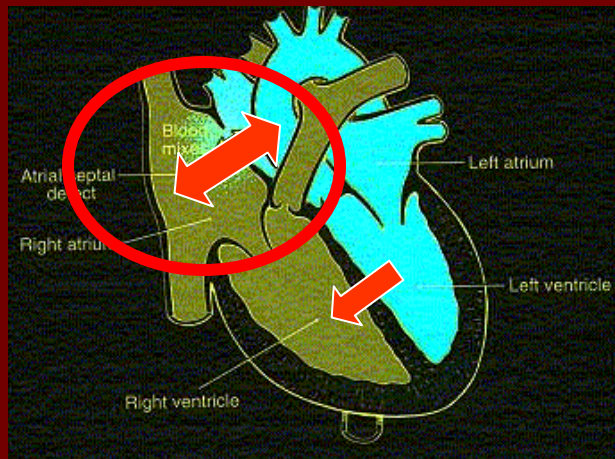
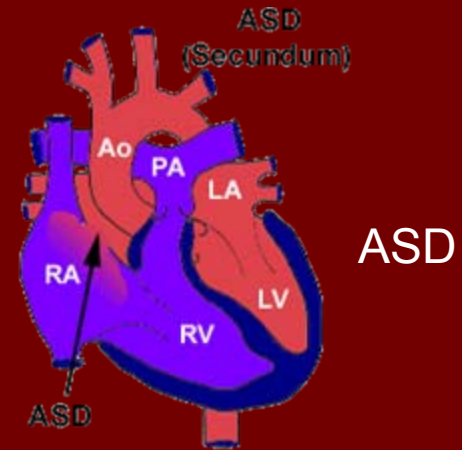
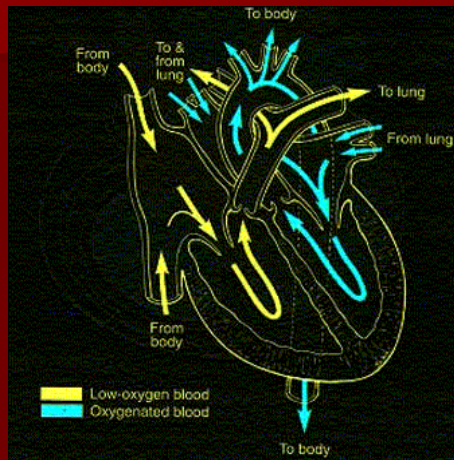
Vascular disease, atrial fibrillation, MI, severe valve disease incidence is low in younger patients

Paradoxical embolic stroke; unique to atrial level shunting emerges as the major cause of stroke in young patients

\*Sources: ACST, AFI meta-analysis, Lausanne Study

# INTRA-CARDIAC RIGHT-TO-LEFT SHUNTING

The mechanism of paradoxical embolism



IN HEALTHY ADULTS, RIGHT-TO-LEFT SHUNT IS UNIQUE TO ASD, PFO, AVM

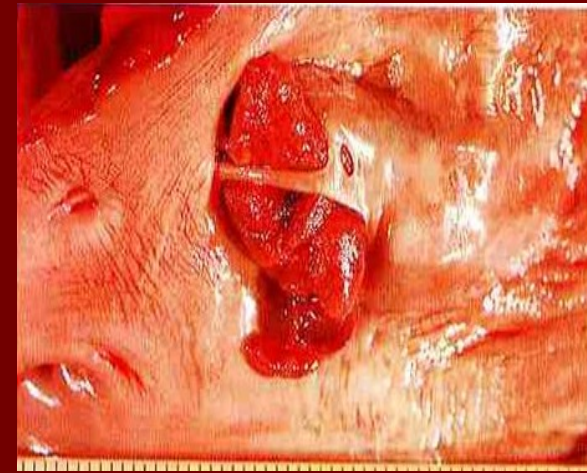
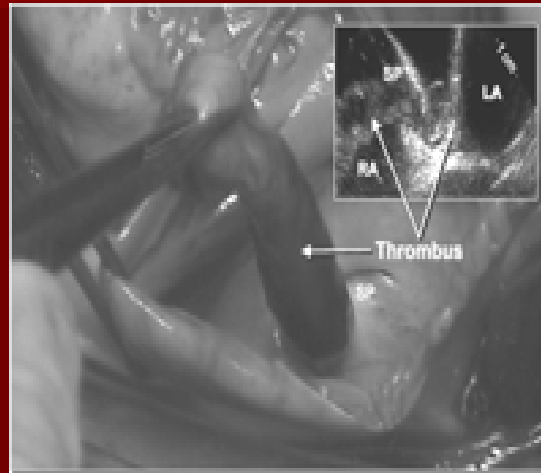
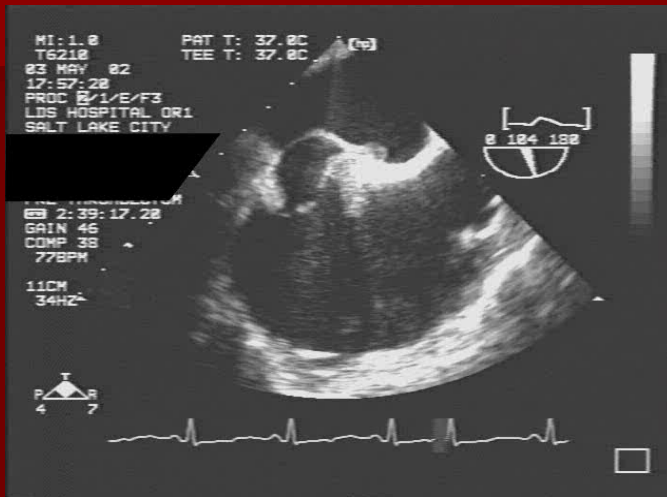
# BACKGROUND

Paradoxical embolism: A breach of neuro-protective filtration by the lungs

- **Paradoxical embolization:** Direct passage of materials from the venous to the systemic circulation; by-passing the ventilatory and non-ventilatory functions of the lungs (coagulation regulation, metabolism, filtration).
- **Paradoxical embolic materials:** de-saturated blood, thrombus, platelet aggregates, gases (scuba diving), fluid embolism (fat droplets), cellular debris (pregnancy and trauma), medical procedural products (bone, air, fat, marrow, cells, thrombus).
- **Paradoxical embolism is common:**
  - Google (paradoxical embolus as key word) = >200,000
  - PubMed (peer reviewed articles) = 750 citations

# THE EVIDENCE

## DIRECT EVIDENCE OF PARADOXICAL EMBOLIZATION (PDE)



**4) ANGIOGRAPHIC** EVIDENCE OF CEREBRAL EMBOLIZATION IN 90% OF PDE / CVA PATIENTS

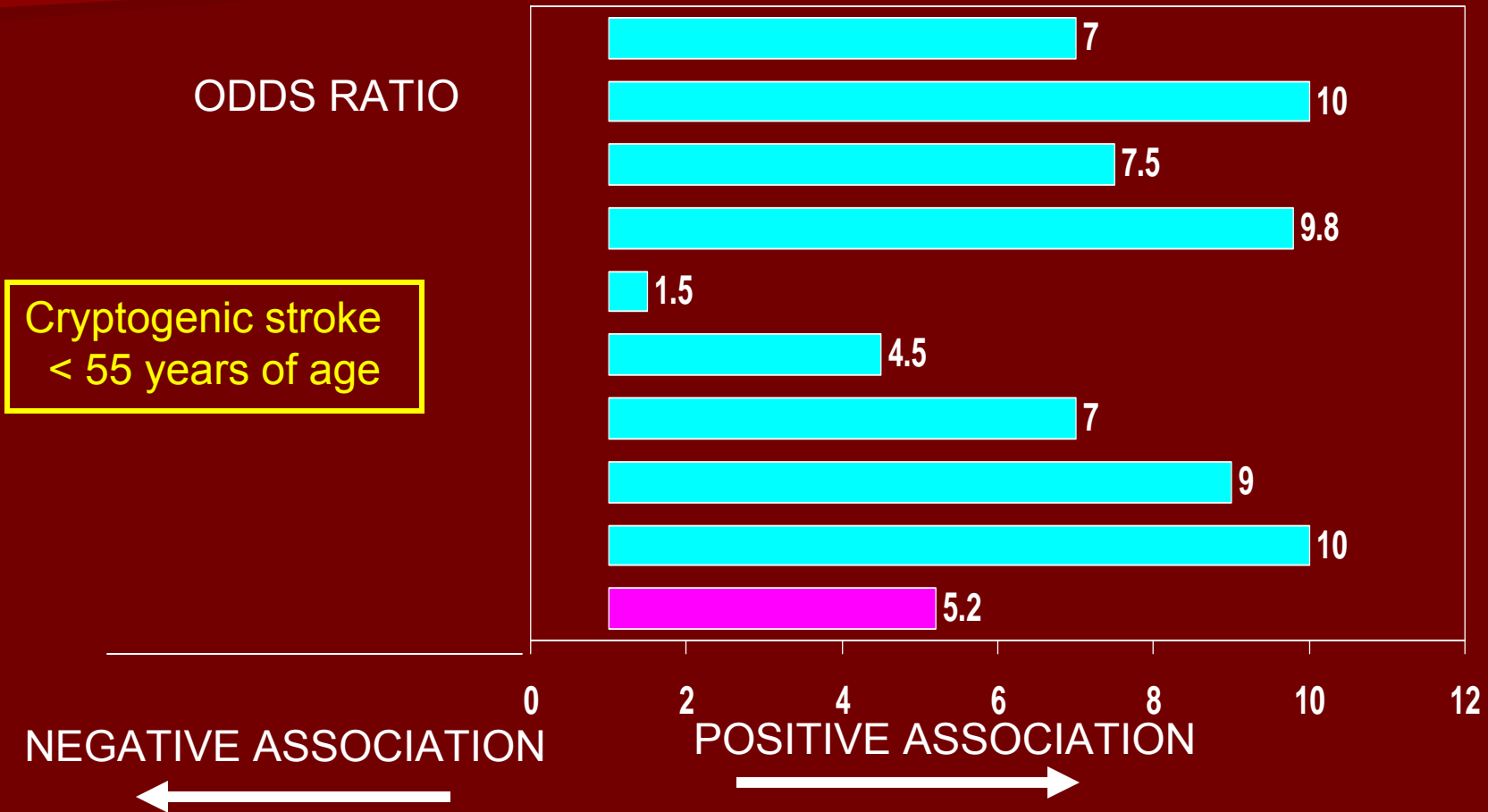
Bogousslavsky J Neurol 1996;46:1301

**5) MEDICAL PROCEDURAL** IMMEDIATE SYSTEMIC EVENTS OCCUR WITH PROCEDURES



# ATRIAL SHUNT STROKE ASSOCIATION

Shunt Diagnosis =  $\geq 1$  bubble\*

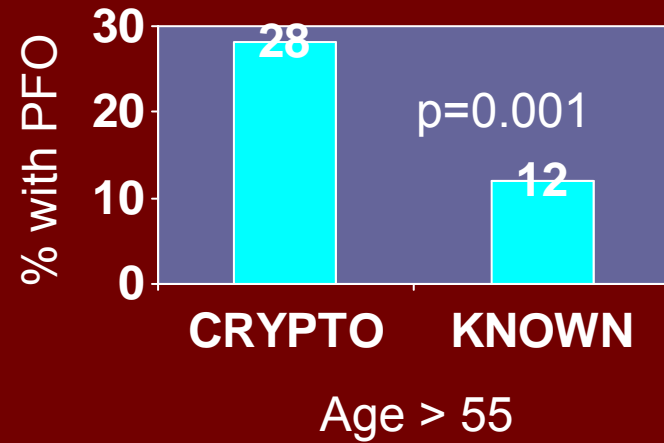
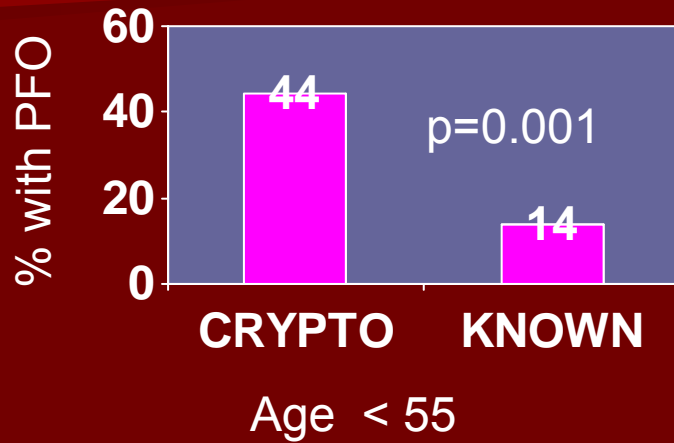


\*includes normal or low risk patients

Overell JR, Neurology 2000; 55:1172

# THE EVIDENCE

Newest evidence of PFO / PDE as an independent cause of stroke



## Handke M et al NEJM Nov 2007: 357:2262-8

- 276 Stroke of KNOWN cause / 272 CRYPTOgenic stroke
- 131 age <55 years of age / 372 age >55 years of age
- Atrial septal Aneurysm (ASA) + PFO in each group

# STROKE

## How are we doing?

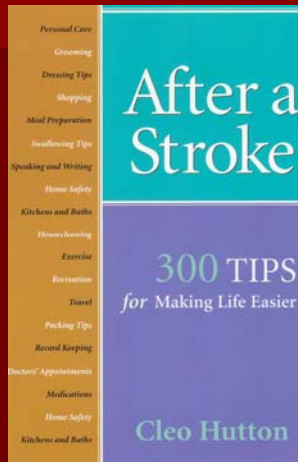


Figure 11. Large, soft grip handles for utensils

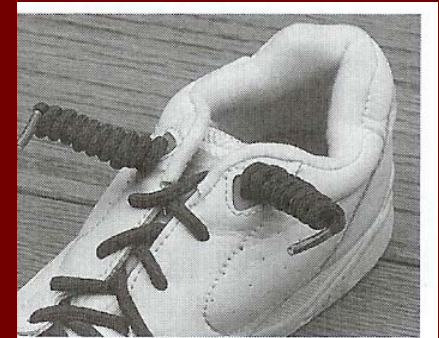


Figure 4. Coiler laces allow for one-handed tying.

Trends in incidence, lifetime risk, severity, and 30 day mortality of stroke over the past 50 years  
Caradang R et al, JAMA 2006; 296:2939-46

9152 patients free of stroke undergoing 50 years of follow-up 1950-1977;; 1978-1989 ; 1990-2004

**30 day mortality**  
**Lifetime stroke risk**  
**Stroke severity**

**Significant decrease for men but not women**  
**No significant reduction**  
**No significant reduction**

# Septal defects increase adverse outcome in a large and varied set of conditions

## MACRO-EMBOLIZATION

- CVA /TIA
- LIVER TRANSPLANTATION
- SURGERY ; ORTHOPEDIC
- CV SURGERY
- PREGNANCY
- AIR TRAVEL
- CENTRAL LINES
- HYPER-COAGULABILITY
- SLEEP APNEA
- DVT / PULMONARY EMBOLI
- PULMONARY HYPERTENSION

## MICRO-EMBOLIZATION / "HUMOURS" / O2

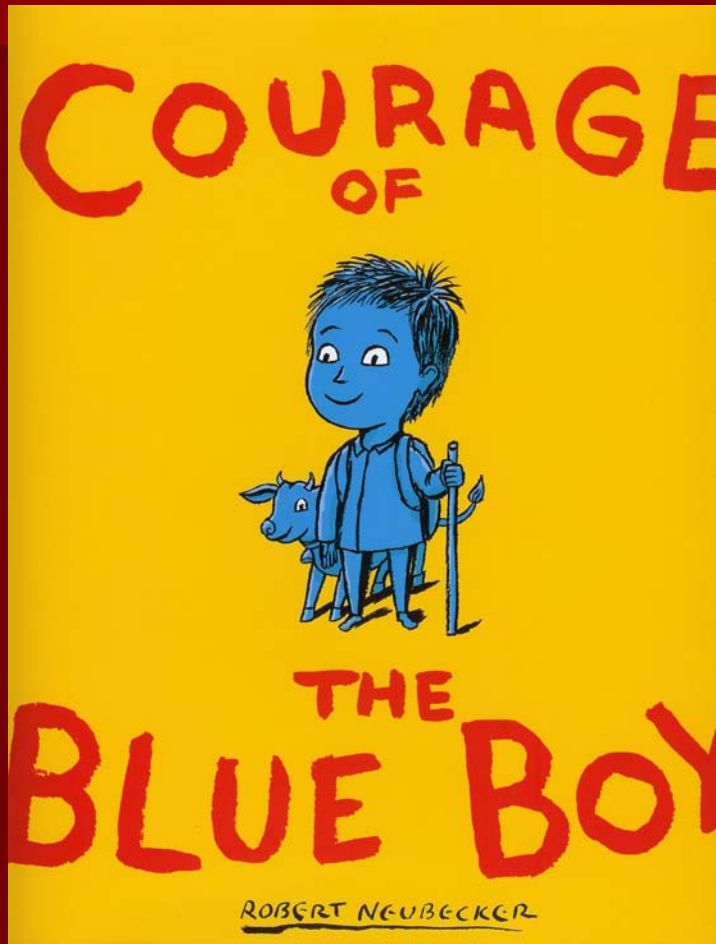
- HYPOXEMIA
- +PRESSURE VENT
- SLEEP APNEA
- COGNITIVE DYSFUNCTION
- ORTHODEOXIA /  
PLATYPNEA
- DIVERS BRAIN / ++MRI
- DECOMPRESSION ILLNESS
- MIGRAINE HEADACHE
  - MIGRAINE STROKE
  - MIGRAINE WMH LOAD

**PARADOXICAL EMBOLIZATION IS GREATLY UNDERDIAGNOSED SINCE IT OCCURS AT LOWER RATES IN A BROAD RANGE OF DISCIPLINES.**



# BLUE BABIES

What cyanotic congenital heart disease children can teach us about PDE



## ■ GERMAN REGISTRY (Schmaltz)

308 CCH children / 8 yrs

### 13% event rate

5 hypoxic events

3 brain abscesses

31 strokes / 56% in first year

### Neurological event risk:

Size of shunt

Duration of shunt

Venous constituents

## MRI CCHD TERM NEONATES (Mahle)

24% PVL / Infarct by MRI

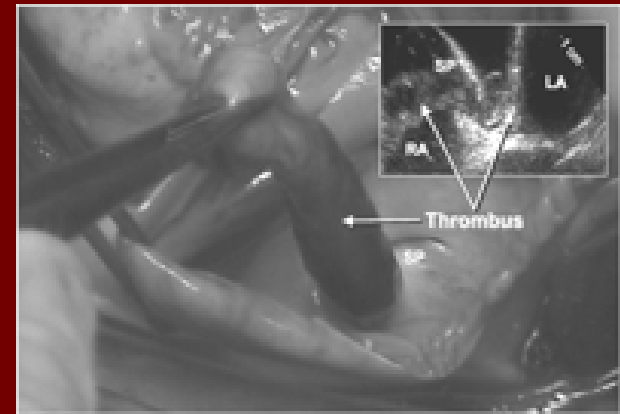
67% new / worse lesions

with heart surgery

# "HAVE A NICE FLIGHT"

Economy Class Stroke; the dangers of deep venous thrombosis

- KAKKOS  
13 pt with CVA soon after long-haul air travel  
58% DVT / 92% PFO
- HECKMAN  
338 CVA / 42 with Recent Travel  
TRAVEL CVA PATIENTS (vs CVA)  
younger  
fewer risk factors  
> posterior circulation CVAs  
> incidence of PFO  
45% vs 11%  
31% vs 6% (<55yrs)  
14% vs 5% (>55 yrs)  
 $p < 0.001$  for all differences
- SORENSEN HT  
42,000 DVT / PE; No CVD  
Significant increase stroke risk



Source: Eur J Vasc Evasc Surg 2004; 27: 239  
Heart 2006; 92: 1265  
Lancet 2007; 370:1773

# CENTRAL VENOUS LINE WOES

Medical procedure paradoxical embolism as proof of mechanism

## JW

50 yr old pilot /BM TX

Port-a-Cath

Catheter flush by wife:

Immediate chest pain (PE)

Paraplegia due to paradoxical embolization of the L-1 anterior spinal artery

Large PFO closed

## SH

35 yo white female

Brief hemi-sensory loss X 2

Port-a Cath for chemotherapy

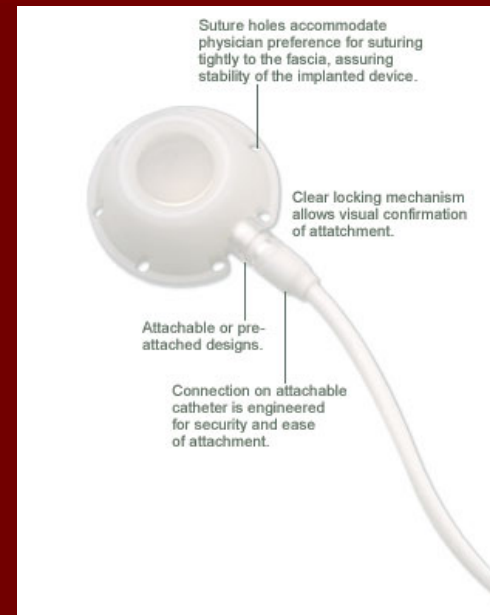
Disabling CVA w/ injection

Hemiparesis and severe aphasia

ASD closed

**5000 pts** with CVAD (IHC data base)

1.8% New stroke / TIA



What about dialysis?

-Doppler proof of severe micro-bubbles in SVC

-May cause even lung compromise

-3 days a week / 52 weeks per year

-50% severe cognitive dysfunction

# THE DEVIL AND THE DEEP BLUE SEA

## Scuba diving and right-to-left shunt



- SCUBA DIVING

  - 3-5 fold DCI II

  - Increased +MRI

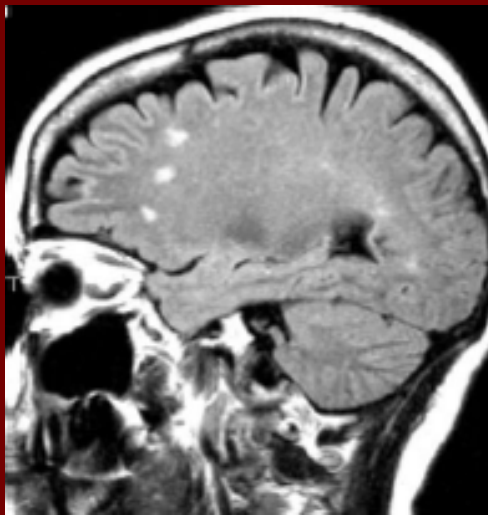
  - Increased MFMRI

- CLIMBERS

  - Increase hypoxia

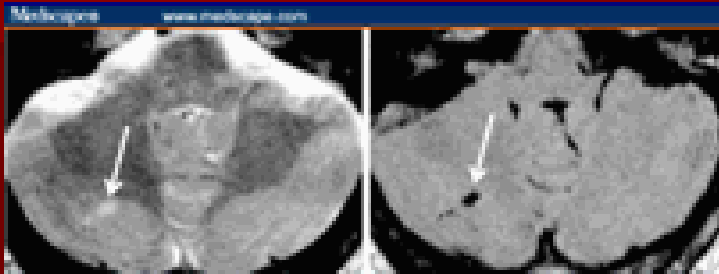
  - Confusional states

  - HAPE



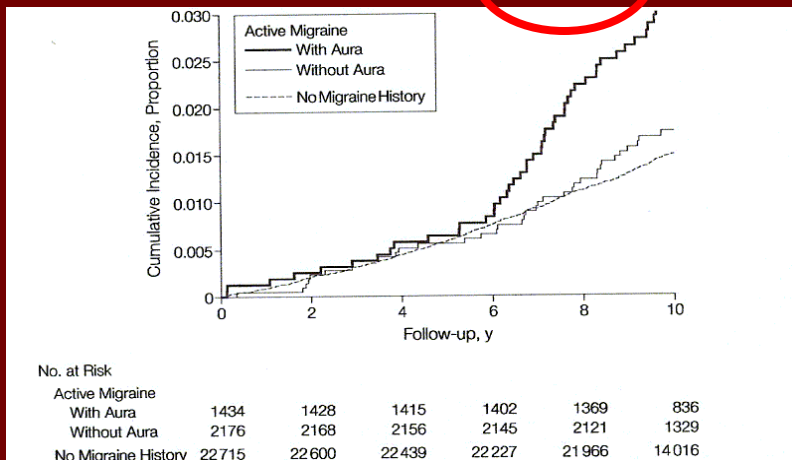
# SHUNT AND MIGRAINE

## POSTERIOR CIRCULATION STROKE



Kruit MC et al; JAMA 2004; 291:427-434

Migraine / aura OR 13.8  
 Migraine / aura / 1pm **OR15.8**



Kurth T et al; JAMA 2006; 296:283-333

Migraine 5125 aura 40%

- 14% OF Americans
- Disabling disorder in 50%
- WHO top 10 disability list
- Lower quality of life than diabetes, RA, heart disease
- 12-20 billion \$ productivity loss
- 40-60% have RLS
- Usually larger shunt
- CVA / Brain lesion association
- Diving association
- 50-80% improvement with PFO, ASD, AVM closure (observational)
- MIST: a negative study (RCT)

# CONCLUSIONS

- Although usually considered a primary vascular disorder, stroke is actually most commonly caused by embolism of the brain by particulate materials of varying size.
- Paradoxical embolism is the most common cause of stroke in young patients as vascular, rhythm, valvular, and cardiac chamber disorders are relatively uncommon.
- Paradoxical embolism is common but occurs in such a variety of circumstances and presentations that it is often under diagnosed or if diagnosed often discounted.

*THANK YOU*