Pathologies Cardiaques Congénitales

Hôpitaux de Bordeaux

C·H·U Hôpitaux de Bordeaux

L'ECHOCARDIOGRAPHIE POUR LA REANIMATION DES CARDIOPATHIES CONGENITALES

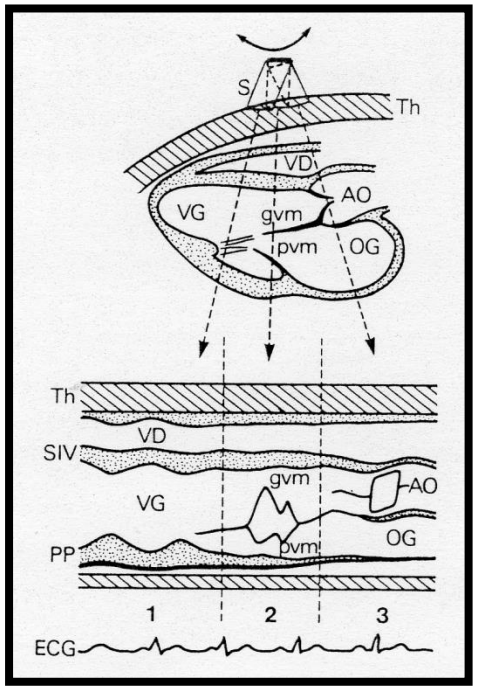
Pierre-Emmanuel Séguéla

DIU Réanimation des Cardiopathies Congénitales

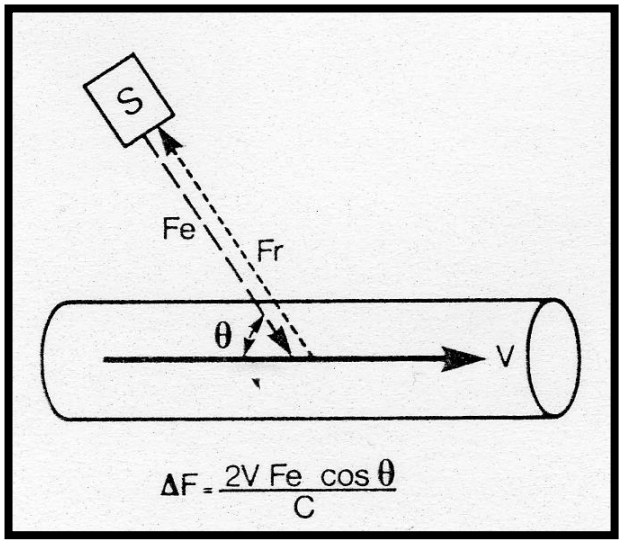
8 Novembre 2018

Rappels

2D et TM



Doppler couleur, DC, DP

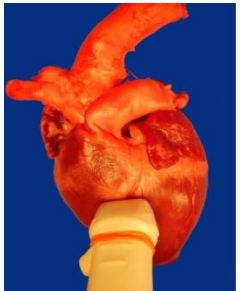


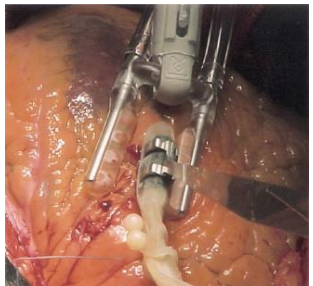
Matériel

- ETT: sonde 4-12 MHz

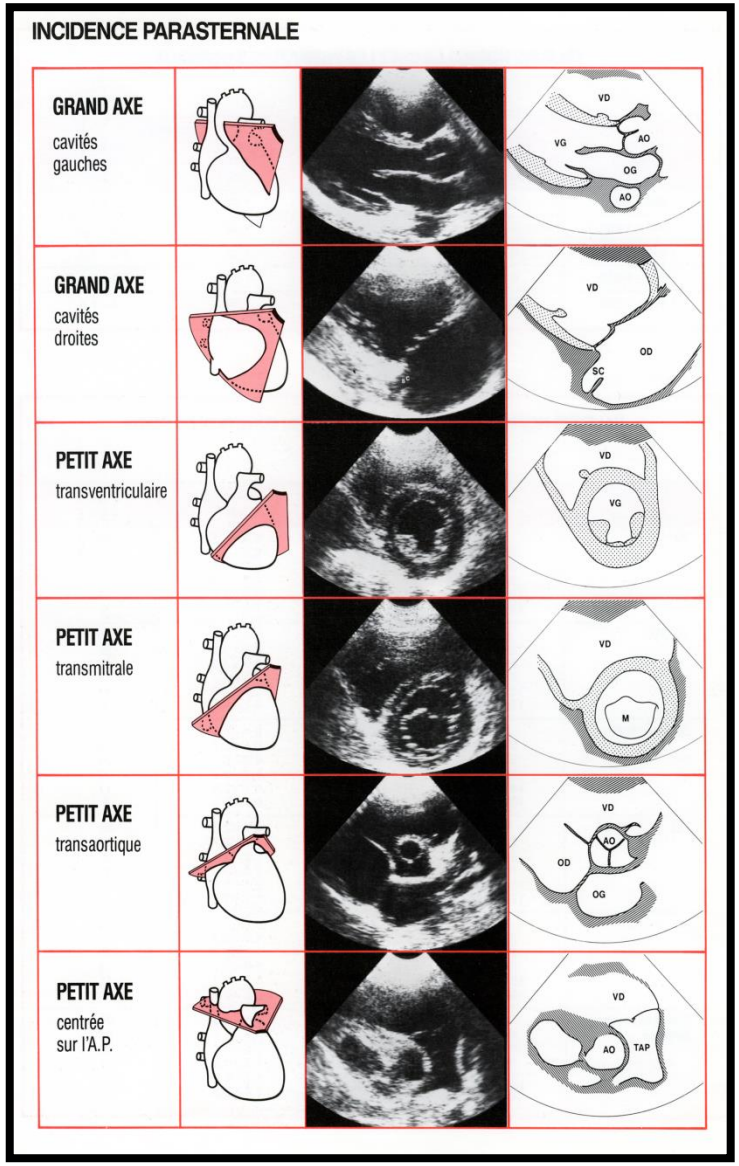
- ETO: à partir de 3kg (sonde mini-multi)

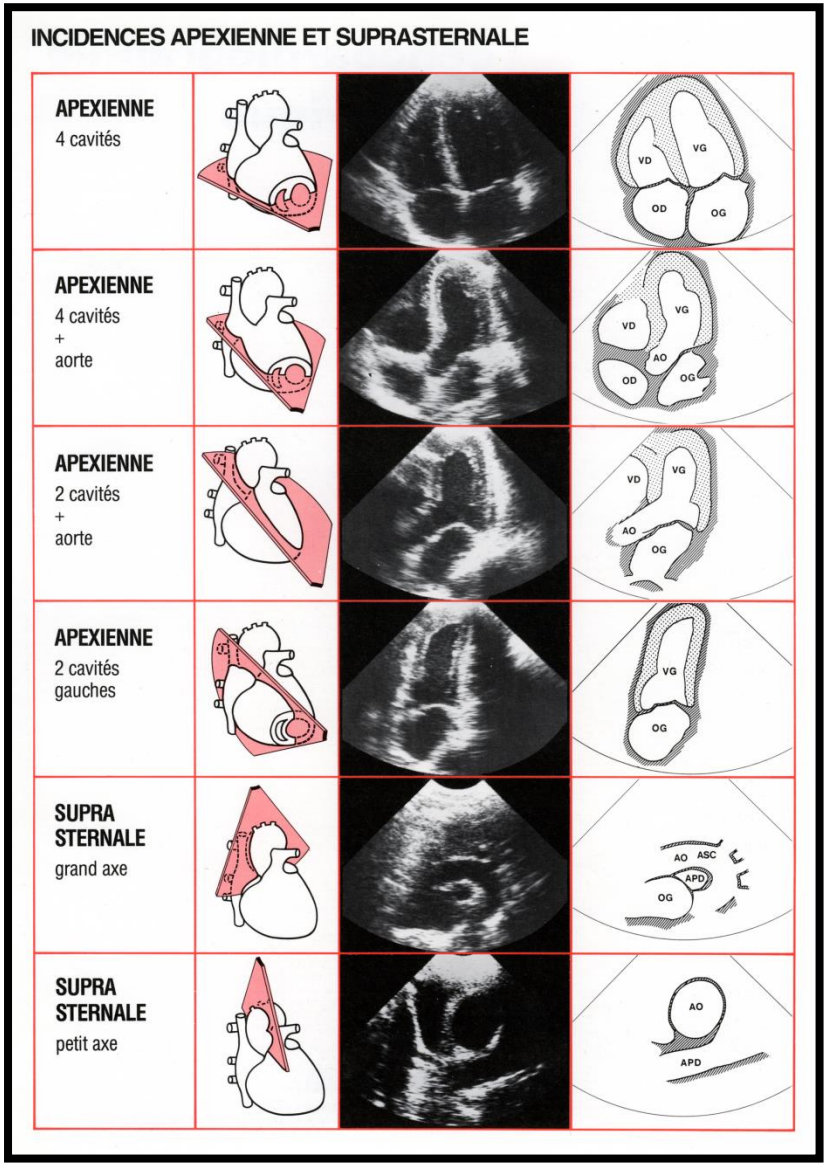
- Echo épicardique



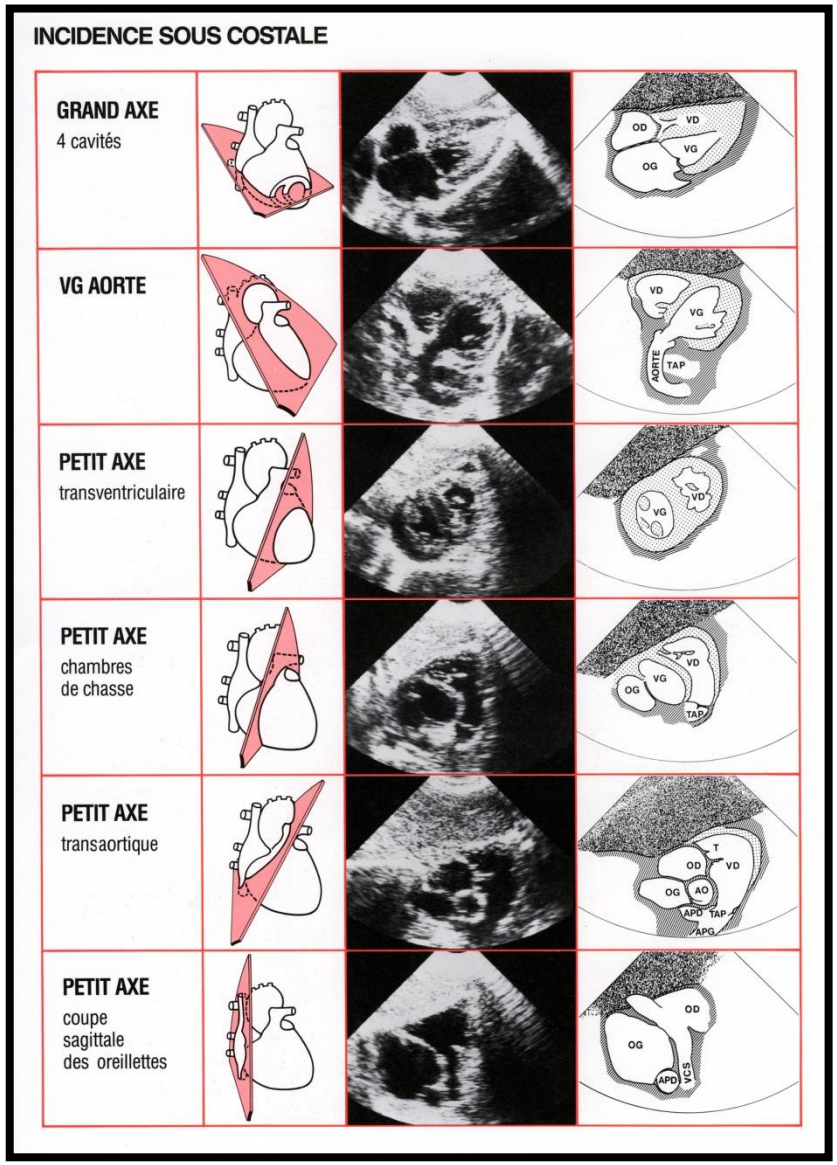


Les incidences en pédiatrie





Incidence sous-costale = incidence clé



⇨ spécifique à la cardiologie pédiatrique

- analyse segmentaire complète

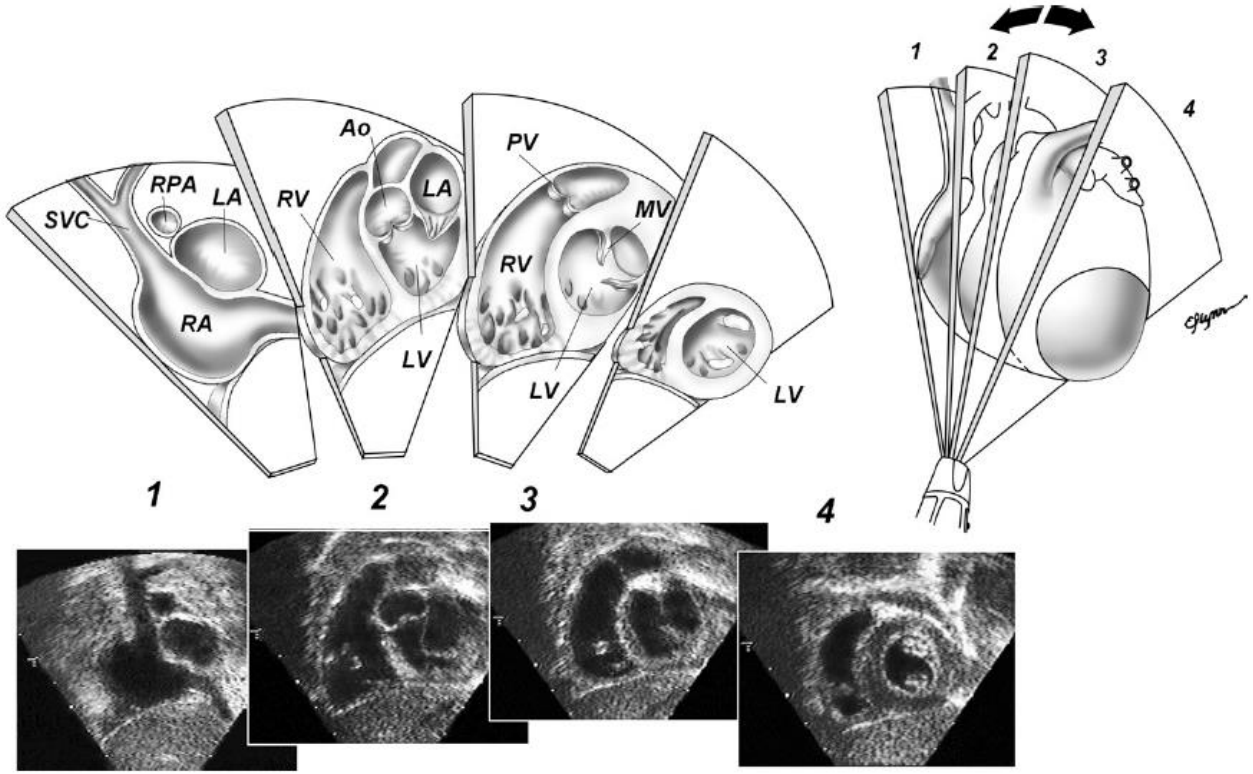
- diagnostic spécifique (RVPAT, CIA)

- parfois seule voie d'abord (Thorax ouvert, ventilation,…)

Guidelines and Standards for Performance of a Pediatric Echocardiogram: A Report from the Task Force of the Pediatric Council of the American Society of Echocardiography

J Am Soc Echocardiogr 2006;19:1413-1430.

Wyman W. Lai, MD, MPH, FASE, Tal Geva, MD, FASE, Girish S. Shirali, MD, Peter C. Frommelt, MD, Richard A. Humes, MD, FASE, Michael M. Brook, MD, Ricardo H. Pignatelli, MD, and Jack Rychik, MD, Writing Committee, *New York, New York; Boston, Massachusetts; Charleston, South Carolina; Milwaukee, Wisconsin; Detroit, Michigan; San Francisco, California; Houston, Texas; and Philadelphia, Pennsylvania*



Quelles valeurs?

VALEURS NORMALES POUR LES NOUVEAUX-NES

(D'après Meyer)

	Meyer	Solinger	Hagan
Nb étudié	50	240	200
Pds (Kg)	2,3 - 4,9 (3,2)	2,27 - 4,54	2,7 - 4
Ao (mm)	7 - 12 (10)	9 - 14	8 - 12
DOG (mm)	6 - 13 (9)	7 - 14	5 - 10
DTDVG (mm)	12 - 20 (16)	16 - 24	12 - 2
VD (mm)	10 - 17 (13)	11 - 22	8 - 19
Epaisseur du septum (mm)	–	2 - 5	2 - 4 (3
Epaisseur PP VG (mm)	–	2 - 5	2 - 4 (
Epaisseur Paroi ant.			
VD (mm)	–	1 - 4	2 - 5 (
AP (mm)	–	11 - 16	09 - 1

VALEURS NORMALES POUR LES ENFANTS EN FONCTION DE LA (SC)

(D'après Feigenbaum)

	SC (m^2)	Moyenne (cm)	valeurs ex (cm	
VD	< 0,5 0,6 à 1,0 1,1 à 1,5 > 1,5	0,8 1,0 1,2 1,3	0,3 - 0,4 - 0,7 - 0,8 -	
VG-DTD	< 0,5 0,6 à 1,0 1,1 à 1,5 > 1,5	2,4 3,4 4,0 4,7	1,3 - 2,4 - 3,3 - 4,2 -	
Epaisseur S, PP	< 0,5 0,6 à 1,0 1,1 à 1,5 > 1,5	0,5 0,6 0,7 0,8	0,4 - 0,5 - 0,6 - 0,7 -	
OG	< 0,5 0,6 à 1,0 1,1 à 1,5 > 1,5	1,7 2,1 2,4 2,8	0,7 - 1,8 - 2,0 - 2,1 -	
Ao	< 0,5 0,6 à 1,0 1,1 à 1,5 > 1,5	1,2 1,8 2,2 2,4	0,7 - 1,4 - 1,7 - 2,7 2,0 - 2,8	29 11
Ouverture valves aortiques	0,5 0,6 à 1,0 1,1 à 1,5 > 1,5	0,8 1,3 1,6 1,8	0,5 - 1,0 0,9 - 1,6 1,3 - 1,9 1,5 - 2,0	24 39 29 11

Table 2 LVM (g) and LVMI ($g/m^{2.7}$) percentile values

Age	Gender	n	Variable	Percentile 10th	25th	50th	75th	90th
< 6 mo	Boys	62	LVM	7.22	9.04	10.94	14.16	16.28
			LVMI	40.19	46.92	56.44	66.41	75.72
	Girls	43	LVM	7.59	9.27	11.15	13.76	16.05
			LVMI	39.05	48.62	55.38	65.98	73.47
6 mo ≤ 2 y	Boys	73	LVM	16.95	20.25	23.88	27.84	32.47
			LVMI	36.17	40.66	44.95	53.29	61.27
	Girls	53	LVM	15.39	17.45	22.25	26.46	31.98
			LVMI	32.91	38.67	42.04	49.85	52.86
2 ≤ 4 y	Boys	124	LVM	24.37	28.52	33.31	38.79	45.48
			LVMI	28.44	33.88	39.5	45.19	48.74
	Girls	84	LVM	24.7	28.4	33.34	38.15	43.88
			LVMI	28.87	31.85	37.88	43.11	47.65
4 ≤ 6 y	Boys	133	LVM	34.36	39.13	45.49	52.62	59.26
			LVMI	27.68	30.68	36.96	40.2	45.12
	Girls	111	LVM	29.24	34.57	39.67	46.59	50.38
			LVMI	25.85	28.06	32.29	36.43	43.47
6 ≤ 8 y	Boys	117	LVM	40.23	45.14	51.73	62.06	70.48
			LVMI	24.47	28.56	31.79	36.28	40.18
	Girls	110	LVM	36.88	40.6	48.38	55.84	65.54
			LVMI	23.15	25.77	29.71	33.15	37.73
8 ≤ 10 y	Boys	111	LVM	45.32	51.49	62.09	73.42	84.61
			LVMI	22.45	24.85	29.11	34.57	38.25
	Girls	99	LVM	39.22	48.08	54.76	70.87	75.49
			LVMI	19.07	22.12	26.63	30.37	34.3
10 ≤ 12 y	Boys	122	LVM	57.76	66.28	74.1	89.43	105.3
			LVMI	21.88	24.71	28.18	31.87	36.42
	Girls	92	LVM	57.12	62.94	71.66	85.44	98
			LVMI	20.22	23.25	26.11	29.63	33.05
12 ≤ 14 y	Boys	180	LVM	66.88	82.5	97.76	117.8	138.1
			LVMI	21.02	24.38	28.8	32.84	39.08
	Girls	144	LVM	60.79	78.37	92.36	108.8	119.8
			LVMI	20.47	23.63	26.68	29.86	34.65
14 ≤ 16 y	Boys	194	LVM	90.53	106.9	125.7	145.3	167.2
			LVMI	22.22	25.11	28.77	33.49	38.47
	Girls	167	LVM	72.67	84.97	98.73	114.7	130
			LVMI	20.89	23.55	26.51	29.97	34.89
≥16 y	Boys	151	LVM	93.1	111.3	131.5	154	183.1
			LVMI	20.72	24.62	29	32.81	37.73
	Girls	103	LVM	73.9	85.06	101.6	118.8	139.5
			LVMI	20.06	22.94	26.35	31.4	37.93

LVMI, LVM index.

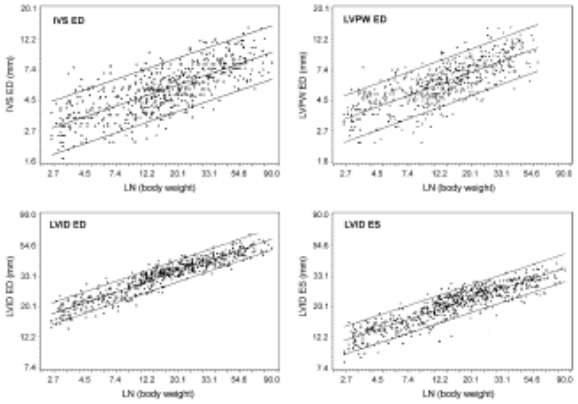


Figure 4 New nomograms of interventricular septum (IVS), left ventricle posterior wall (LVPW), left ventricle inner dimension at end diastole (LVID ED) and at end systole (LVID ES). Dots: boys, stars: girls.

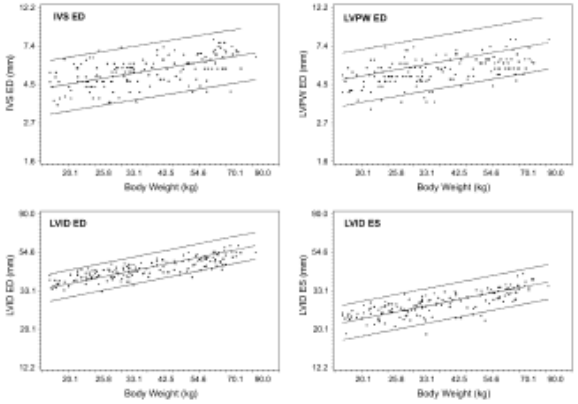
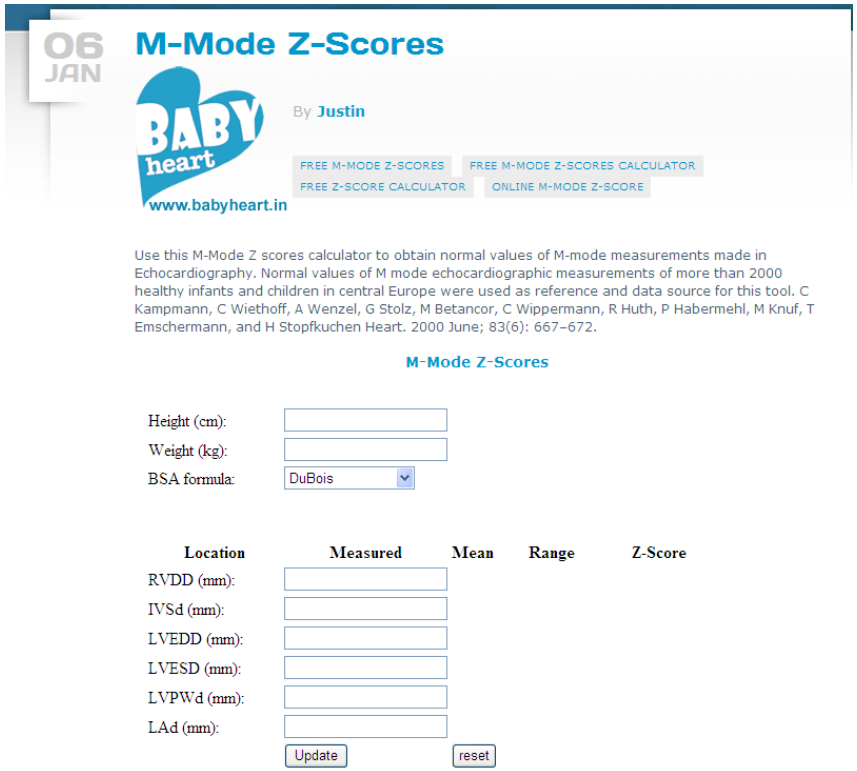


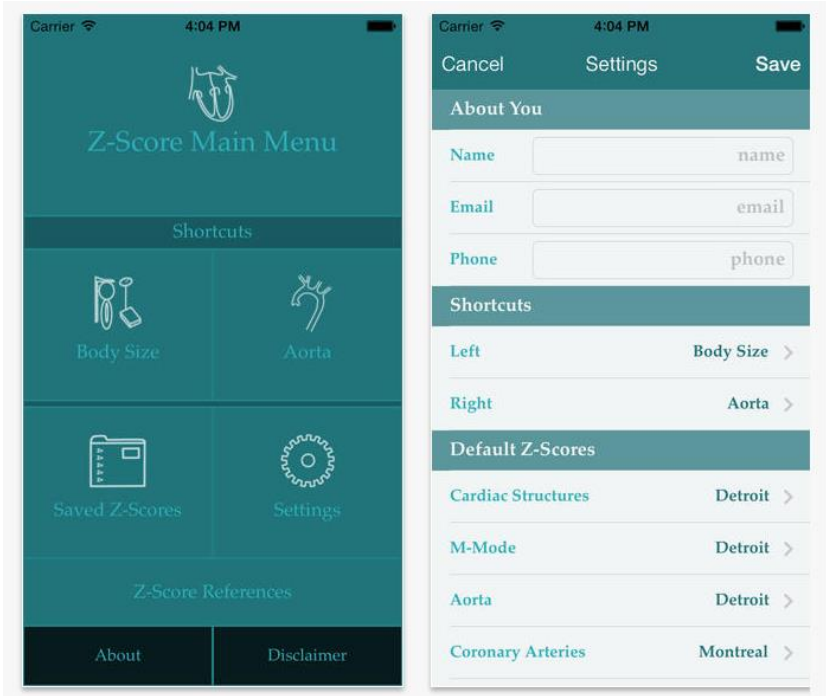
Figure 5 New reference ranges (solid lines) and cardiac dimensions of study group 2 (dots) plotted against body weight. IVS = interventricular septum, LVPW = left ventricle posterior wall, LVID (ED) = left ventricle inner dimension at end diastole, LVID (ES) = left ventricle posterior wall at end systole.

En pratique



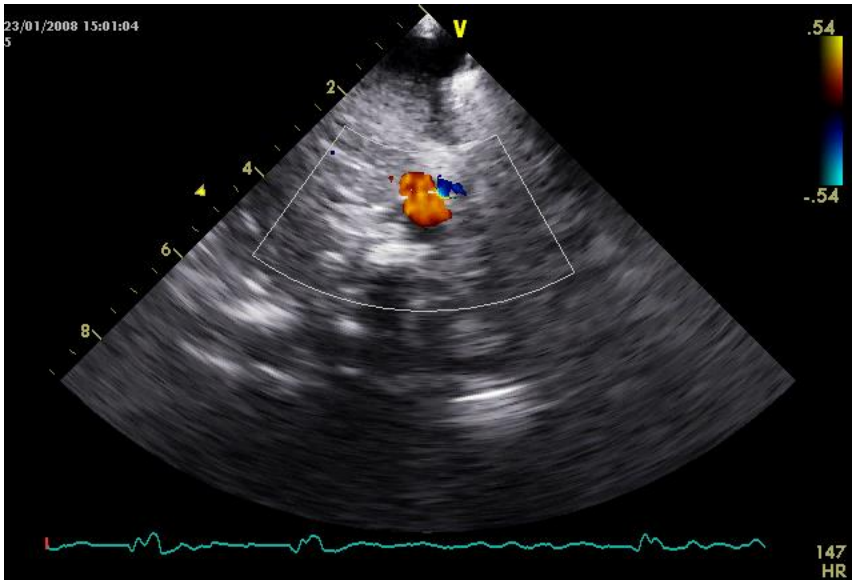
http://babyheart.in/category/medical/z-score-calculator/

Cardio Z



⇨ Z-scores +++

Incidence sous-costale

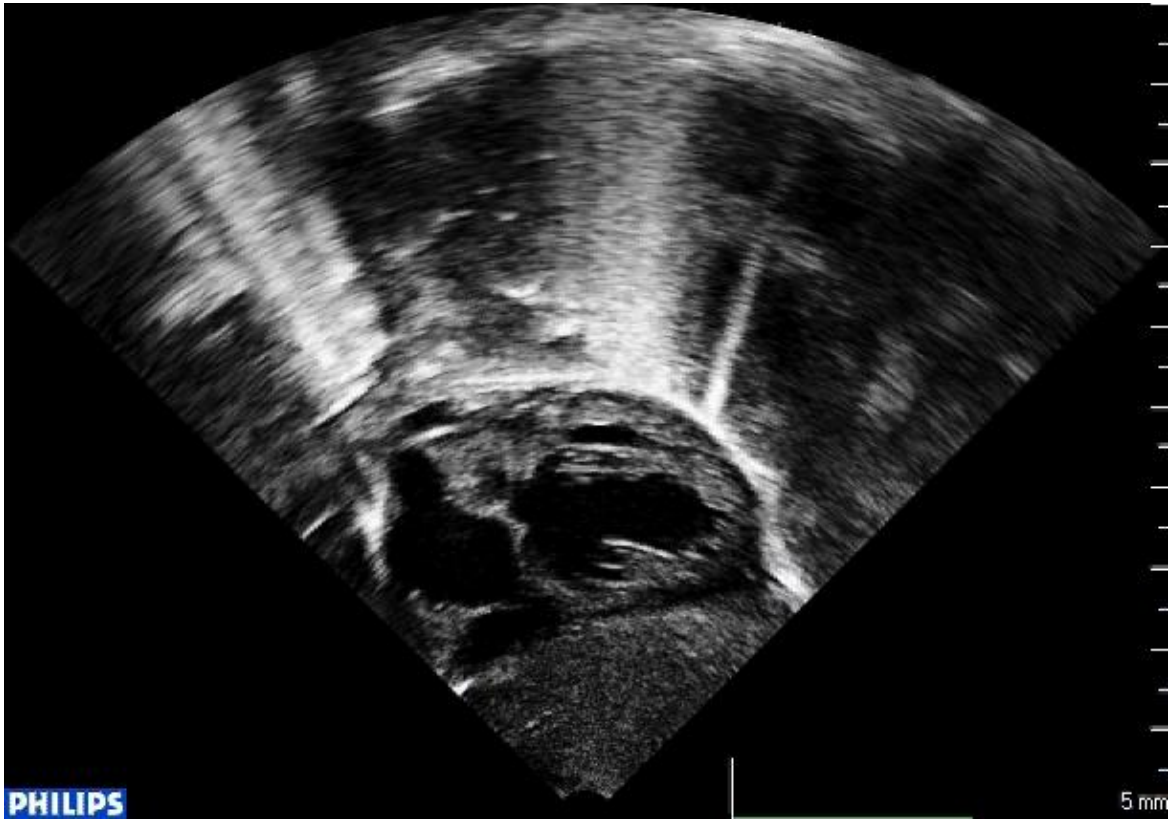


Situs

Incidence sous-costale

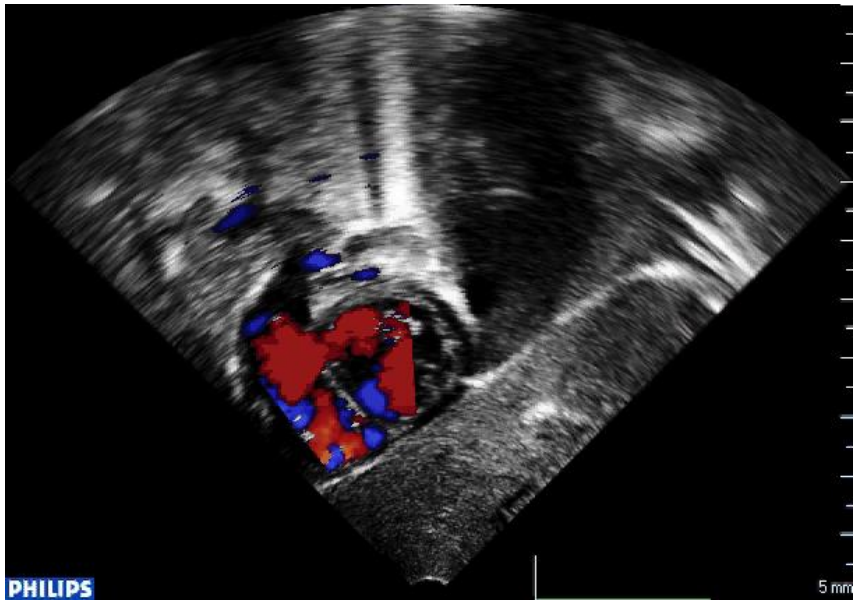
Septum atrial

Incidence sous-costale



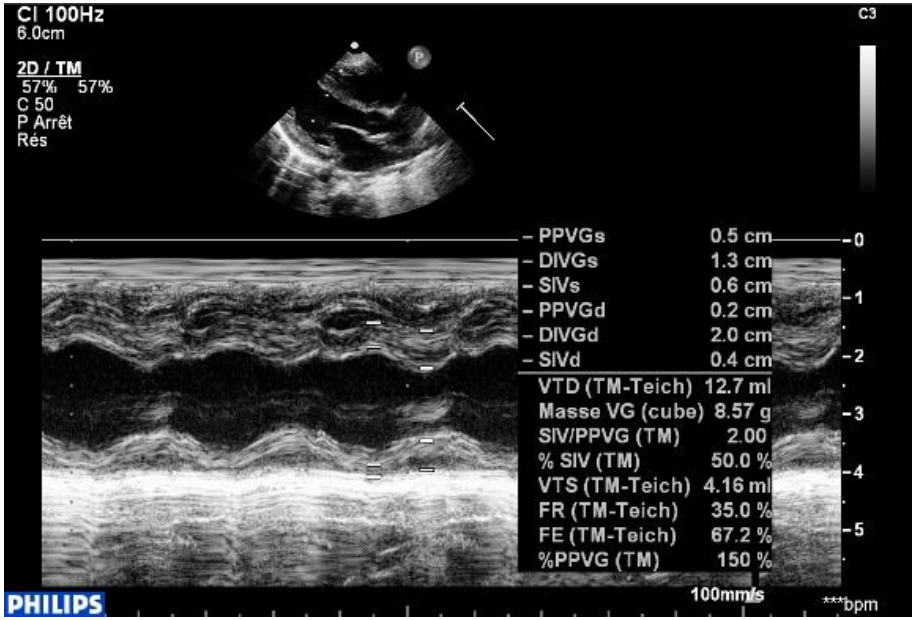
Concordance AV

Incidence sous-costale



Concordance VA

Incidence Para-sternale



⇨ **Fonction VG (TM)**

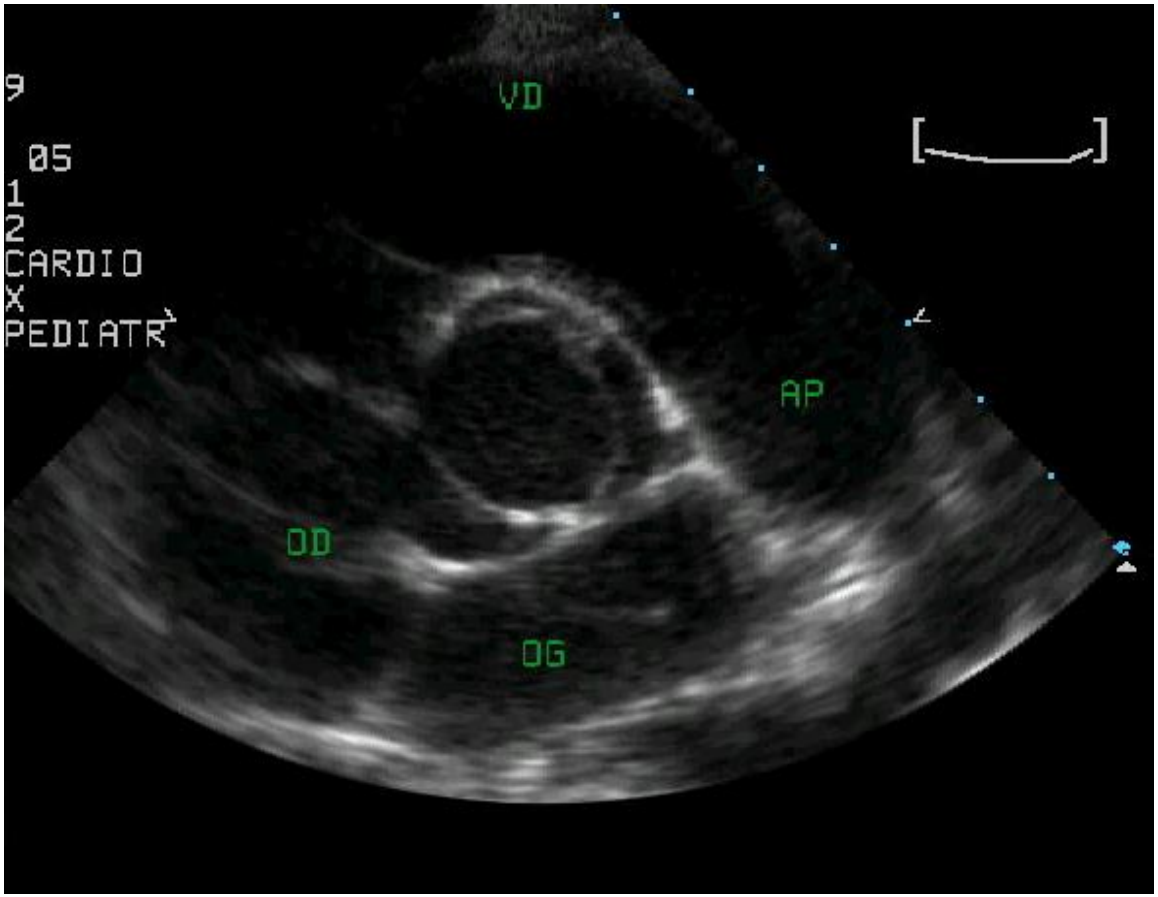
⇨ **Zone sous aortique, Valve mitrale**

Bascule antérieure: voie pulmonaire

Bascule postérieure: valve tricuspide

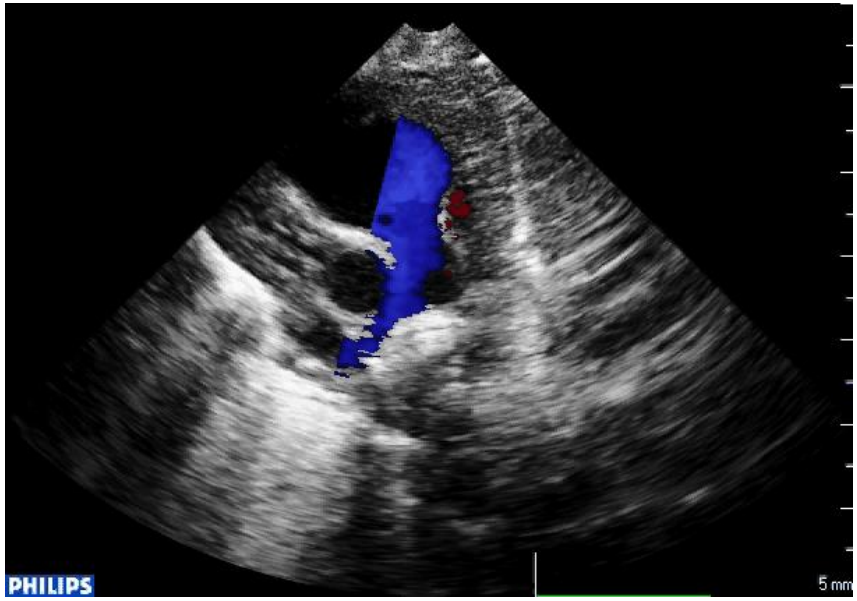
Grand Axe

Incidence Para-sternale



Petit Axe

Incidence Para-sternale



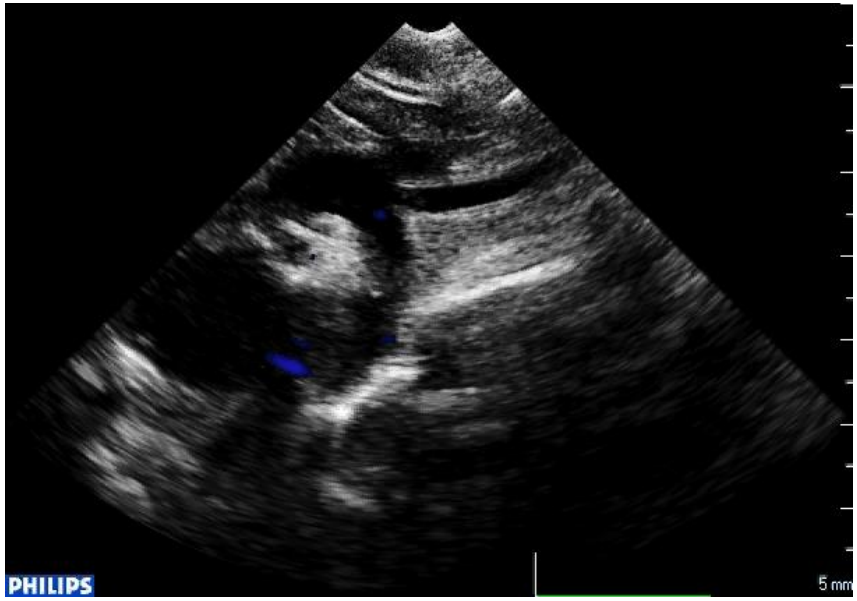
Petit Axe

Incidence Apicale 4 cavités

- Analyse de la jonction AV (croix du cœur)

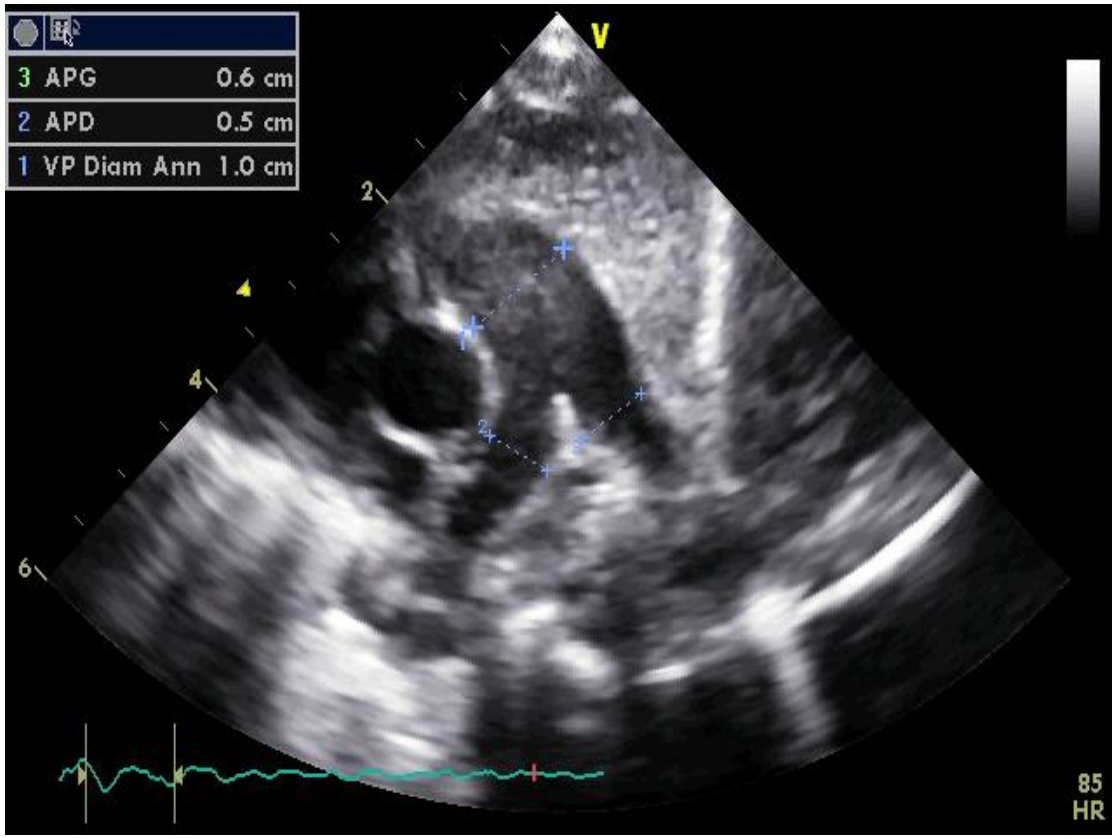
- Valve tricuspide: insertion plus apicale que la valve mitrale

Incidence Supra-sternale



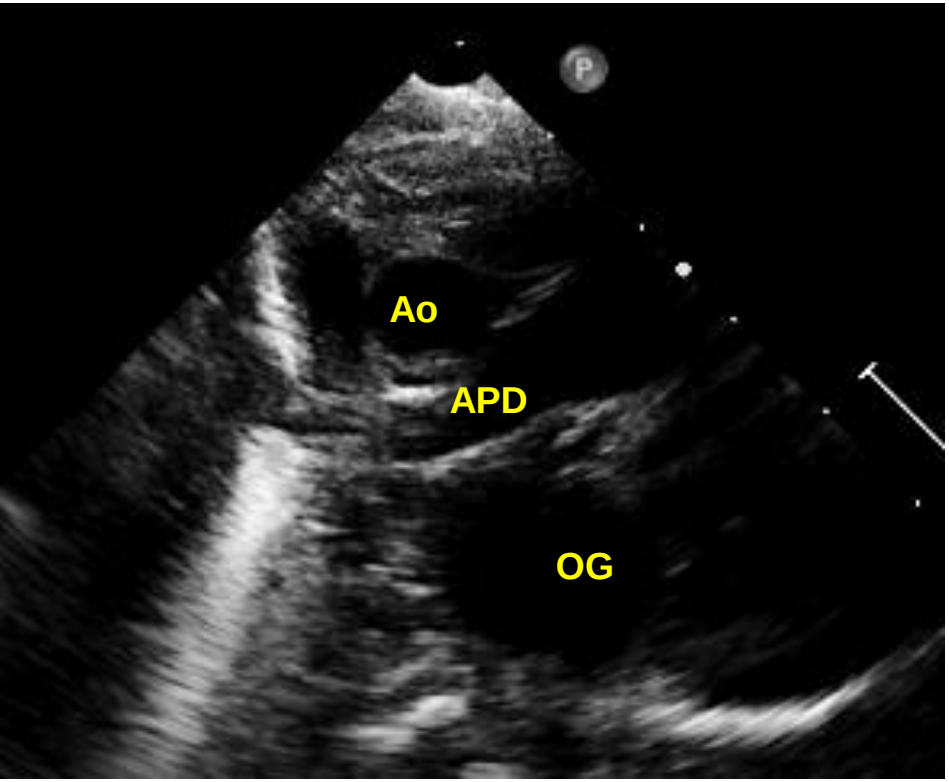
Crosse de l’aorte

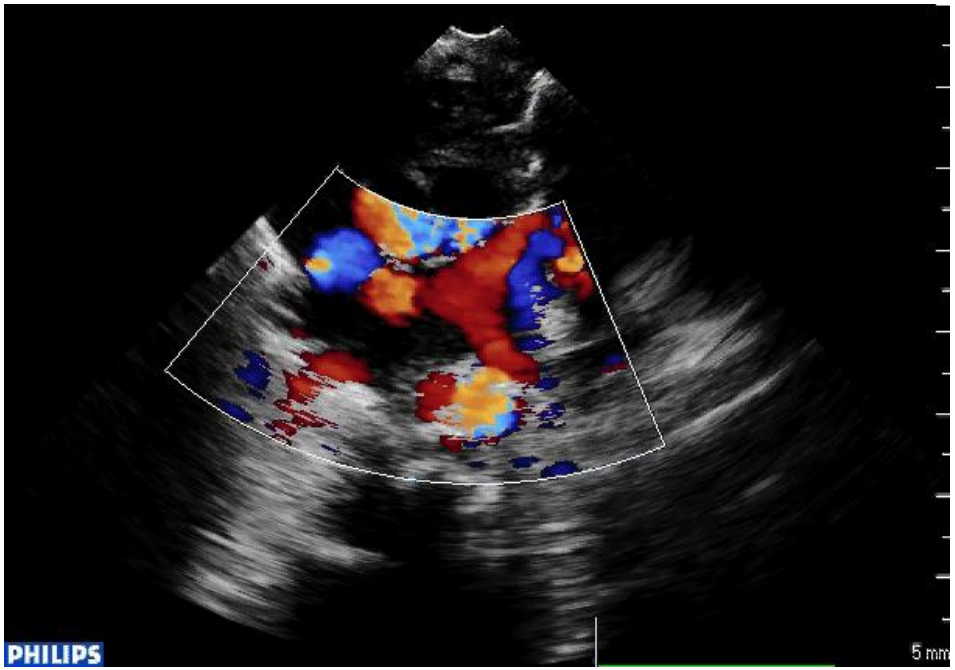
Incidence Supra-sternale



Artère pulmonaire

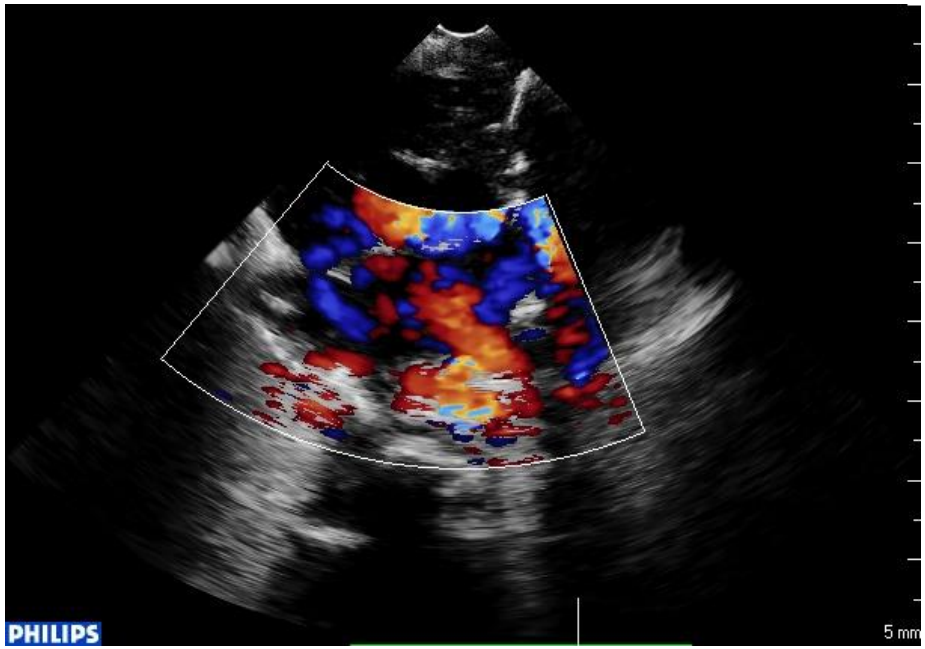
Incidence Supra-sternale



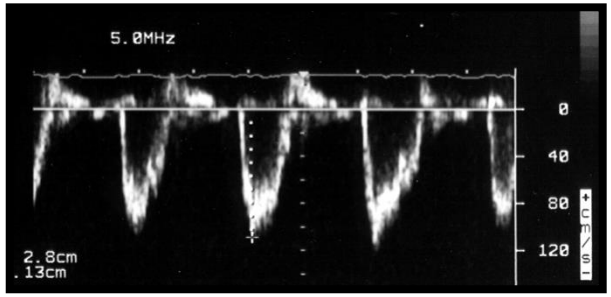


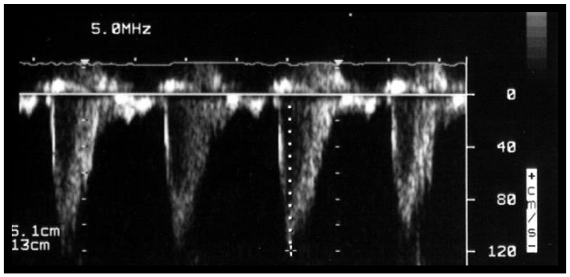
Coupe papillon/crabe = Veines pulmonaires

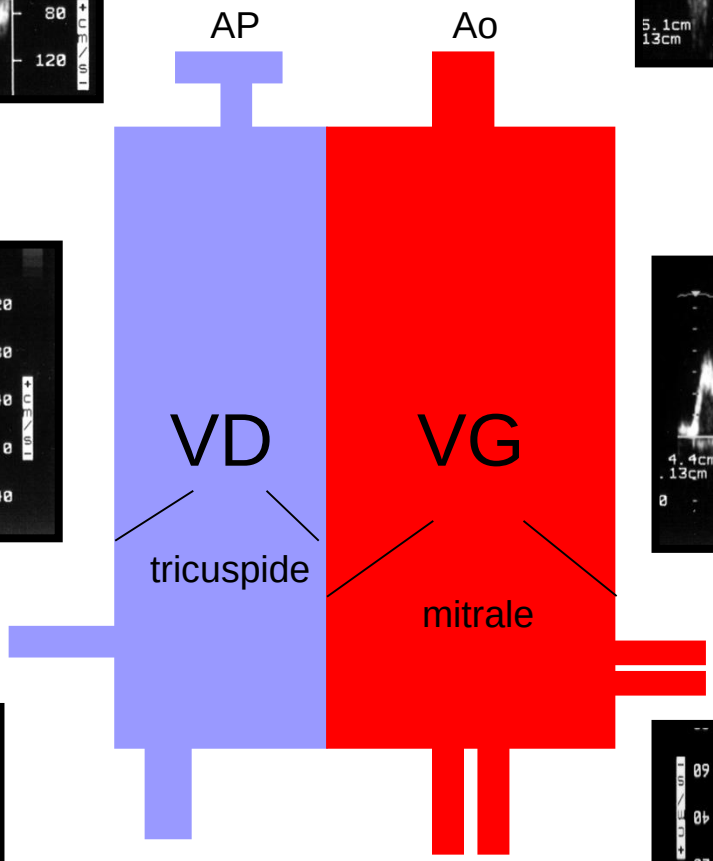
Analyse des veines pulmonaires

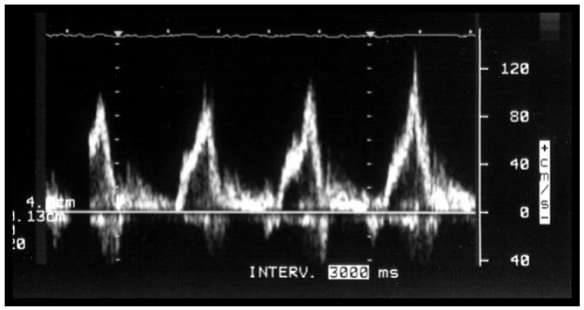


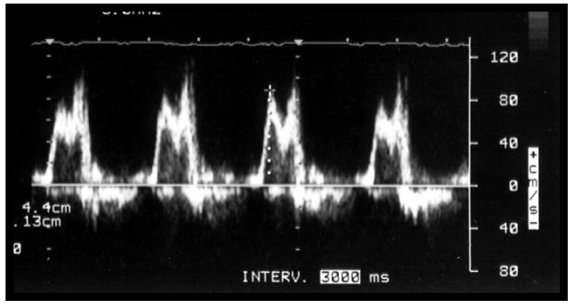
Etude Doppler

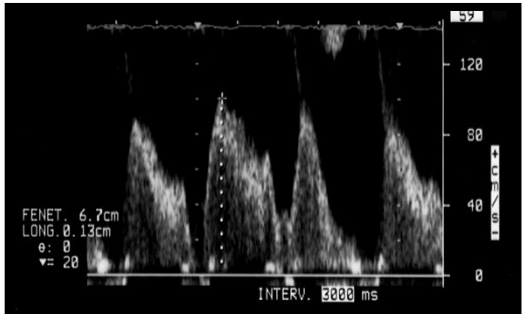


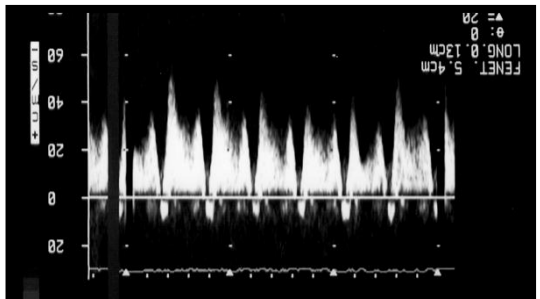












Echocardiographie pré-opératoire

- **Affirme le diagnostic**: anatomie précise de la malformation

⇨ Élément clé de la stratégie chirurgicale

⇨ Aide pour établir une stratégie d'anesthésie et de réanimation

- **Evaluation de l'hémodynamique pré-op**

- Qualité des shunts (CIA/Rashkind, CA)

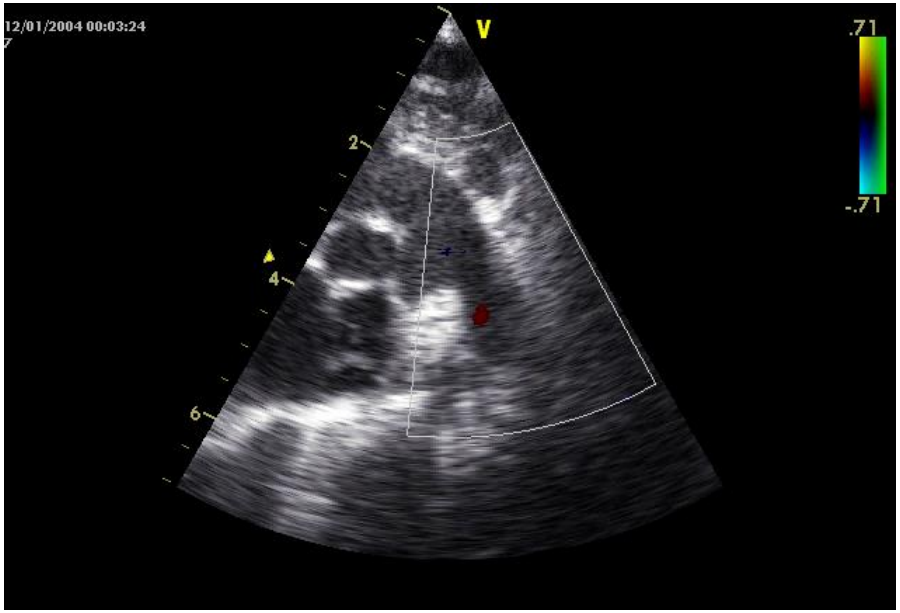
- Fonction VG

⇨ Aide pour la prise en charge médicale pré-op (inotropes, prostine,…)

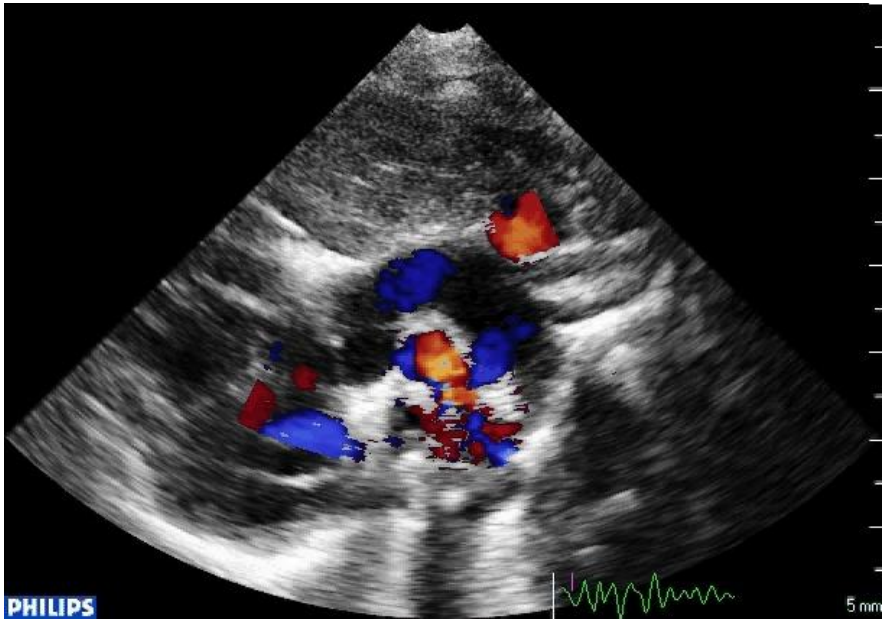
Echocardiographie pré-opératoire

- **Hémodynamique pré-opératoire**

- Évaluation de la ducto-dépendance d'une cardiopathie



Coarctation: shunt D-G

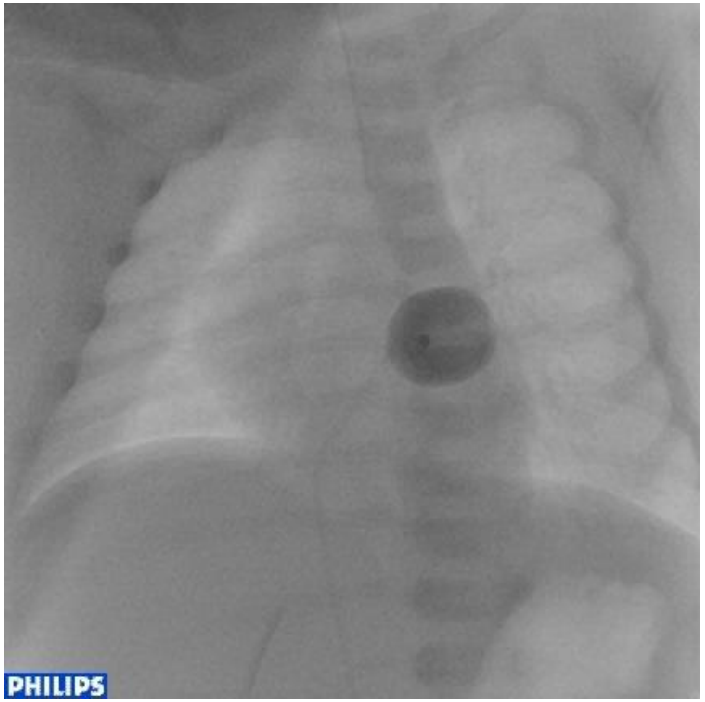


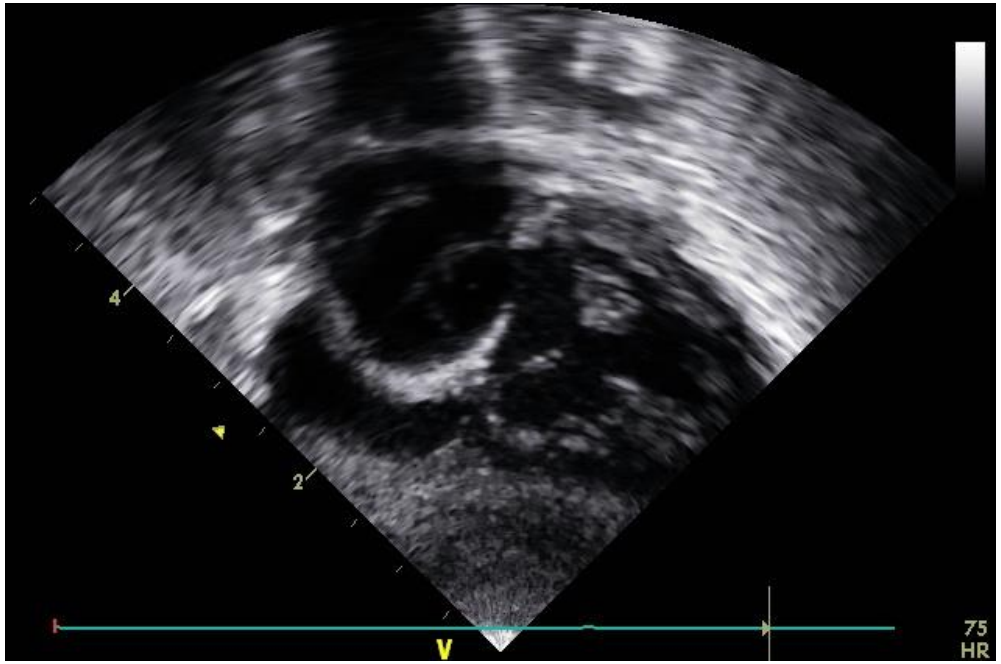
APSO: shunt G-D

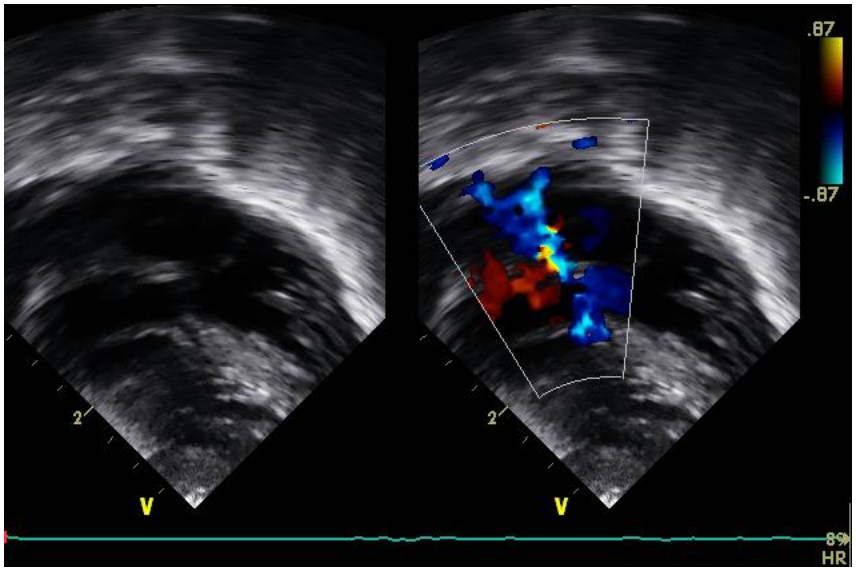
Echocardiographie pré-opératoire

- **Hémodynamique pré-opératoire**

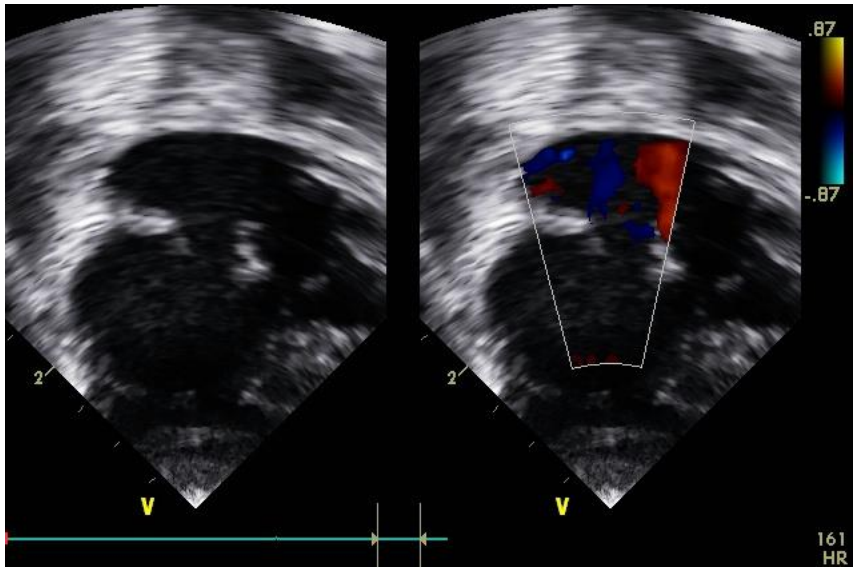
- Évaluation de la qualité d’un Rashkind







Avant

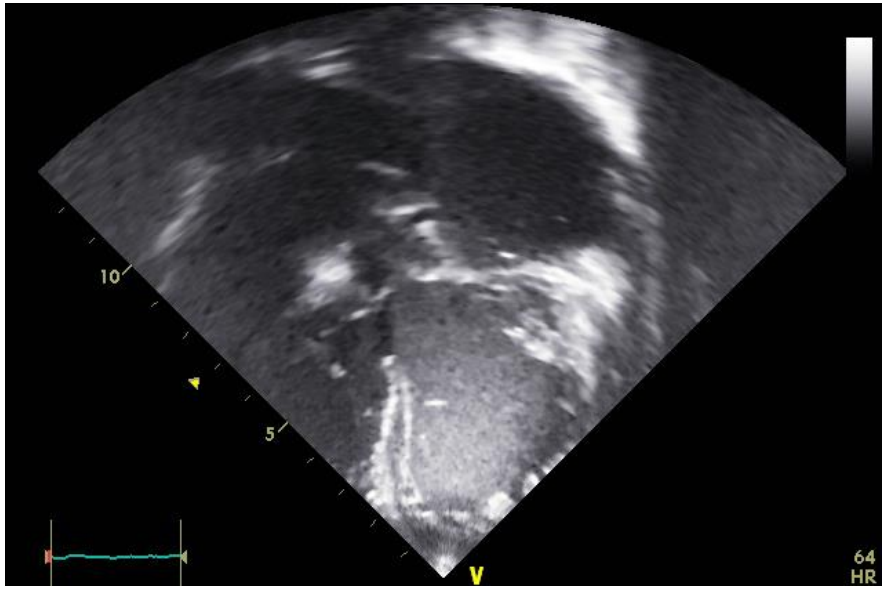


Après

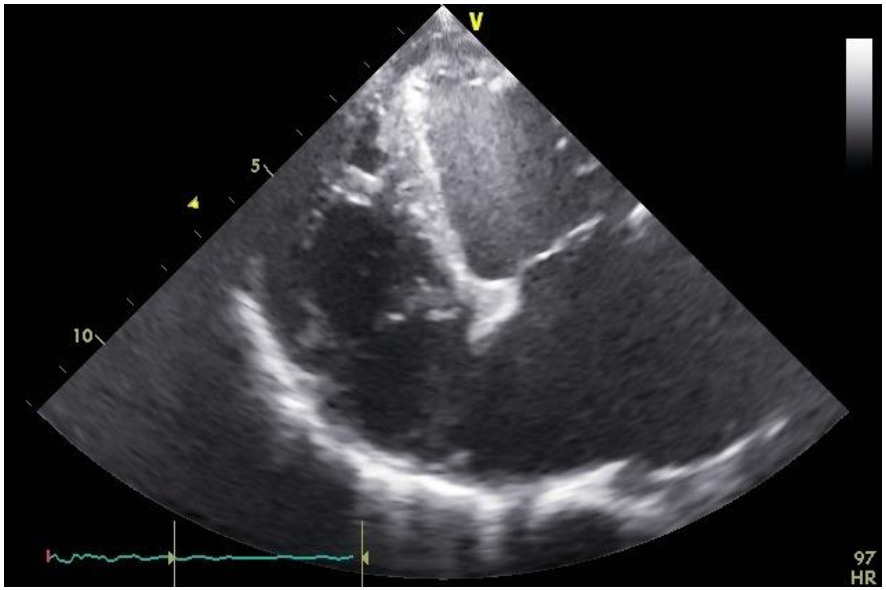
Echocardiographie pré-opératoire

- **Prévoir la stratégie d'anesthésie/réanimation**

- Évaluation de la qualité du VG



5 ans CIV large



Post-op: assistance

Echocardiographie pré-opératoire

- **Prévoir la stratégie d'anesthésie/réanimation**

- Évaluation de la qualité du VD

  Tétralogie de Fallot réparée et non réparée

  VD systémique

  Hypoplasie VG

  Transposition des gros vaisseaux

  Cardiomyopathie

  Greffe cardiaque

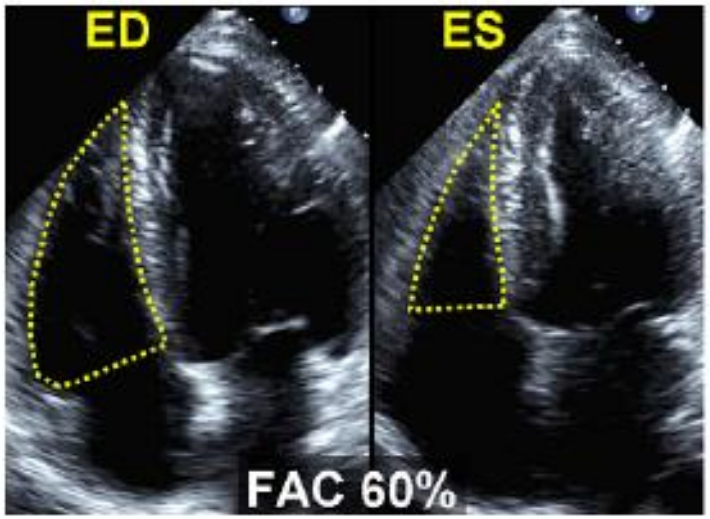
  HTAP

Evaluation VD

- **Fraction de raccourcissement de surface**

- Apicale 4 cavités:

$$FR = \frac{\text{surf diastole} - \text{surf systole}}{\text{surf diastole}}$$



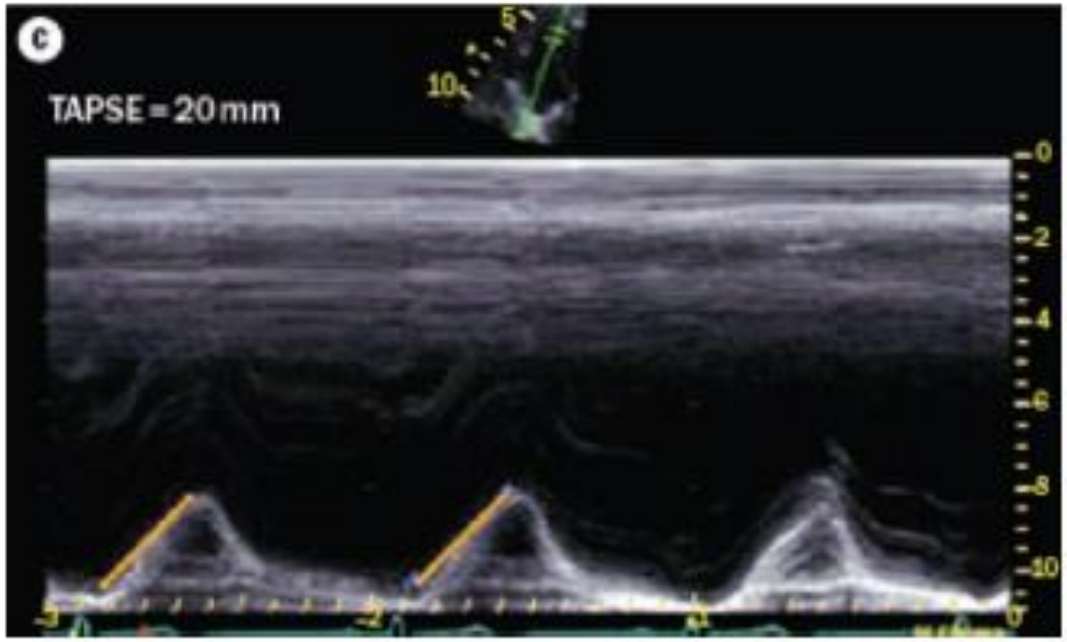
Normale sup 35%

Evaluation VD

- **TAPSE (Tricuspid Annular Plane Systolic Excursion)**

= reflet de l'intégrité paroi libre VD et septum

corrélé +++ à la FEVD isotopique



Evaluation VD

- **TAPSE (Tricuspid Annular Plane Systolic Excursion)**

Right Ventricular Function in Infants, Children and Adolescents: Reference Values of the Tricuspid Annular Plane Systolic Excursion (TAPSE) in 640 Healthy Patients and Calculation of *z* Score Values

Martin Koestenberger, MD, William Ravekes, MD, Allen D. Everett, MD, Hans Peter Stueger, PhD, Bernd Heinzl, MD, Andreas Gamillscheg, MD, Gerhard Cvirn, PhD, Arnulf Boysen, MD, Andrea Fandl, MD, and Bert Nagel, MD, *Graz, Austria*

J Am Soc Echocardiogr 2009

Table 1 Classification table for TAPSE values

		TAPSE (cm)					BSA (m^2)			
			Bounds for *z*-score ranges							
Age	n	Mean	±2 SD (95%)		±3 SD (99%)		Mean	Minimum	Maximum	Indexed TAPSE mean/BSA mean
0-30 d	41	0.91	0.68	1.15	0.56	1.26	0.22	0.14	0.28	4.13
1-3 mo	45	1.14	0.85	1.42	0.71	1.56	0.29	0.12	0.54	3.93
4-6 mo	20	1.31	1.01	1.65	0.86	1.77	0.34	0.26	0.41	3.85
7-12 mo	22	1.44	1.13	1.77	0.97	1.91	0.40	0.31	0.47	3.6
1 y	25	1.55	1.25	1.88	1.10	2.00	0.47	0.3	0.69	3.29
2 y	39	1.65	1.36	1.94	1.22	2.09	0.53	0.4	0.62	3.11
3 y	27	1.74	1.48	2.02	1.35	2.14	0.63	0.52	0.77	2.76
4 y	47	1.82	1.56	2.07	1.43	2.20	0.70	0.6	0.91	2.6
5 y	29	1.87	1.60	2.13	1.47	2.26	0.77	0.63	0.99	2.42
6 y	41	1.90	1.62	2.18	1.48	2.33	0.82	0.46	1.06	2.31
7 y	32	1.94	1.64	2.25	1.49	2.39	0.94	0.75	1.17	2.06
8 y	23	1.97	1.67	2.28	1.52	2.43	0.97	0.79	1.39	2.03
9 y	20	2.01	1.73	2.30	1.58	2.44	1.00	0.8	1.32	2.01
10 y	27	2.05	1.79	2.31	1.65	2.46	1.15	0.82	1.54	1.78
11 y	25	2.10	1.83	2.36	1.69	2.50	1.28	1.06	1.55	1.64
12 y	18	2.14	1.84	2.43	1.68	2.60	1.39	1.08	1.67	1.53
13 y	20	2.20	1.85	2.54	1.68	2.71	1.48	1.03	1.87	1.48
14 y	35	2.26	1.87	2.65	1.68	2.84	1.55	1.11	1.93	1.45
15 y	25	2.33	1.93	2.75	1.74	2.92	1.59	1.32	1.96	1.46
16 y	34	2.39	1.98	2.78	1.78	3.01	1.66	1.3	2.04	1.43
17 y	27	2.45	2.04	2.88	1.83	3.06	1.77	1.43	2.06	1.38
18 y	21	2.47	2.05	2.91	1.84	3.10	1.79	1.34	2.25	1.37

For each age group, the SD of TAPSE was taken to construct ranges of the mean ± 2 SDs and the mean ± 3 SDs. These ranges represented the expectable normal intervals of deviation for certainty levels of 95% and 99%. Furthermore, the mean, minimum, and maximum of BSA were calculated for the age groups. An index was calculated of mean TAPSE for age divided by mean BSA for each age group.

Evaluation VD

- **TAPSE (Tricuspid Annular Plane Systolic Excursion)**

Review Article

Transthoracic Echocardiography in Children and Young Adults with Congenital Heart Disease

Martin Koestenberger

International Scholarly Research Network
ISRN Pediatrics
Volume 2012, Article ID 753481, 15 pages
doi:10.5402/2012/753481

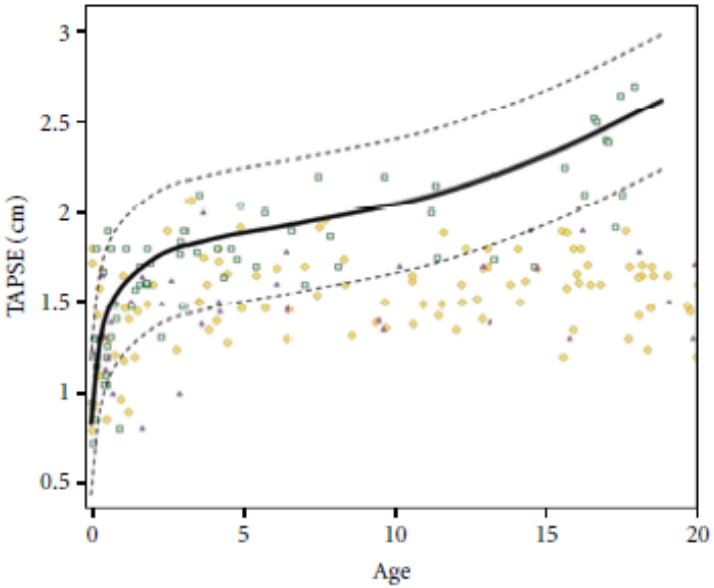


FIGURE 6: Course of TAPSE values in patients with PAH, PS, and TOF from mean reference values versus increasing time period. The TAPSE value data points for PAH, PS, and TOF patients are given as yellow oblique squares, green squares, and purple triangles, respectively. The interpolated mean values of control group are given as the black thin line. The −2 standard deviation line (−2SD) of the control group measurements is given as a grey dashed line. The difference of mean TAPSE values from mean reference values is expressed in centimetre (cm). PS: pulmonary stenosis; PAH: pulmonary artery hypertension; SD: standard deviation; TAPSE: tricuspid annular plane systolic excursion; TOF: tetralogy of Fallot.

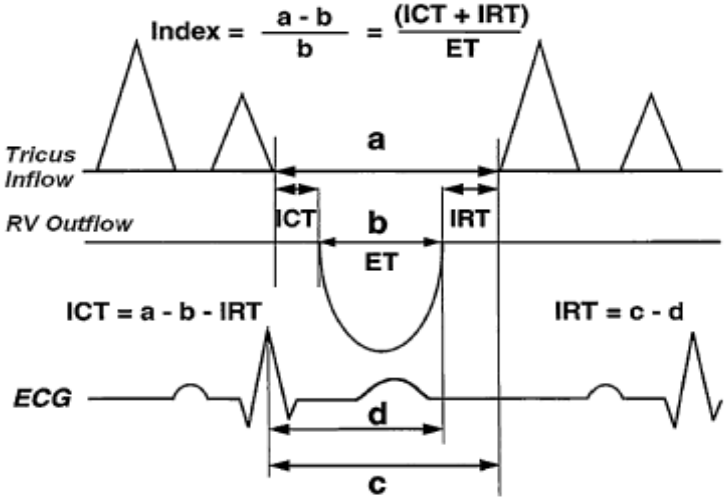
Evaluation VD

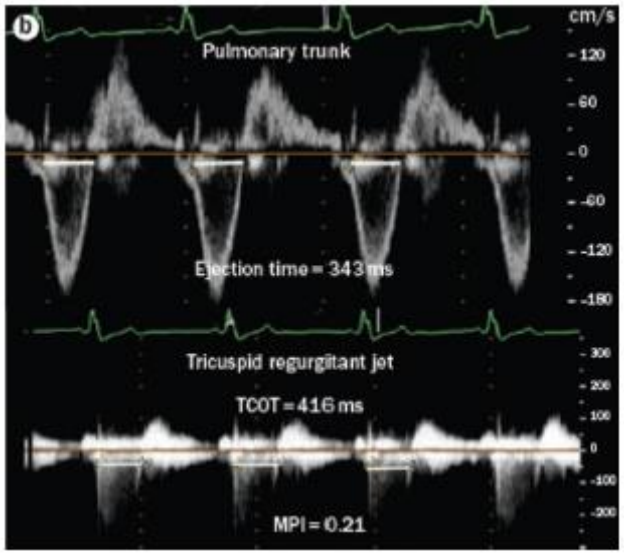
- **Index de performance myocardique (Tei)**

TEI VD = TCI + TRI / TE

TEI VD = a – b / b

Dépend de la pré-charge +++





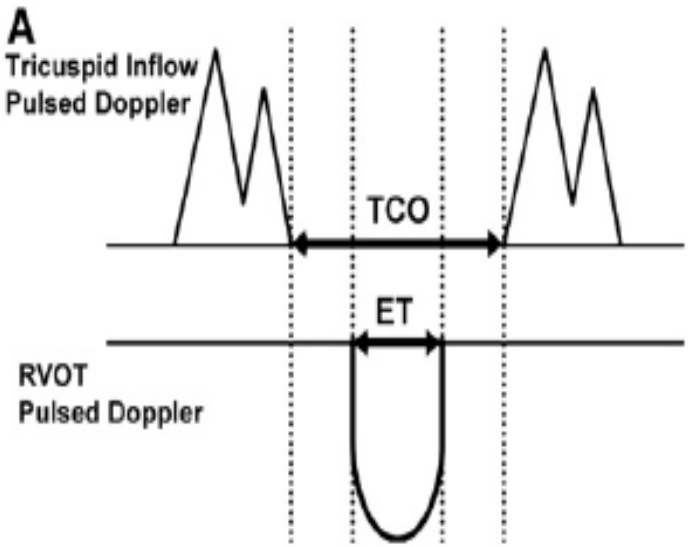
Normale = 0.28 ± 0.04

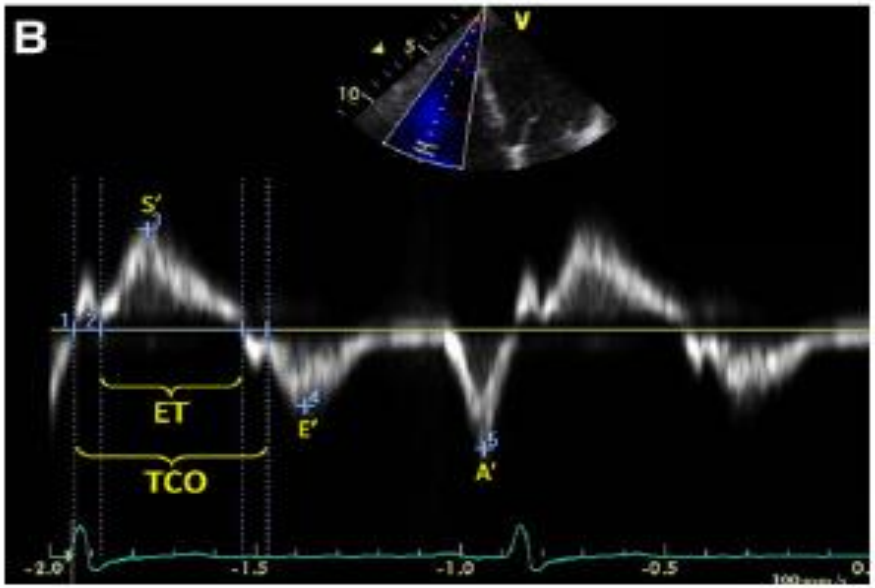
< 0.45-0.5 chez l'adolescent

Evaluation VD

- **Index de performance myocardique (Tei)**

Peut se calculer sur le doppler tissulaire



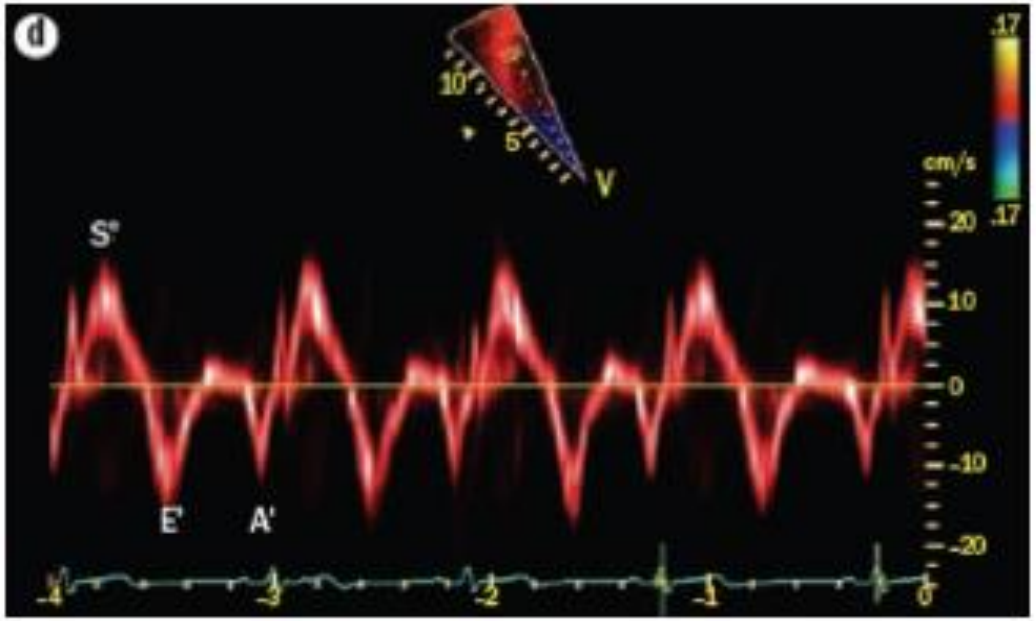


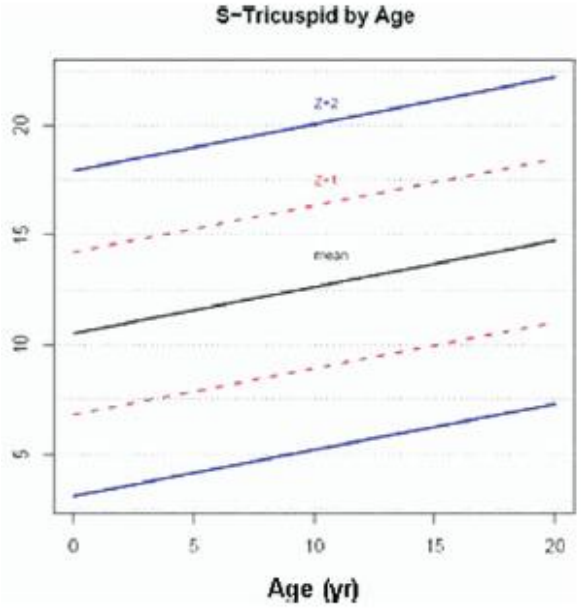
Evaluation VD

- **DTi à l'anneau tricuspide**

Bonne corrélation avec FEVD

Dépend de la post-charge





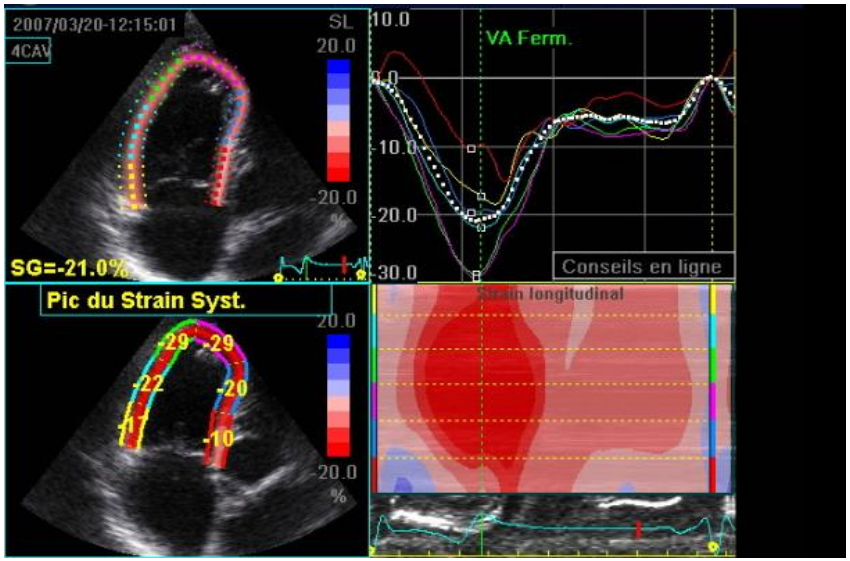
Roberson et al. JASE 2007.

Chez le grand enfant:

Sa : 15.2 ±1.9 cm/sec
Sa < 11.5 cm/s FE< 45%

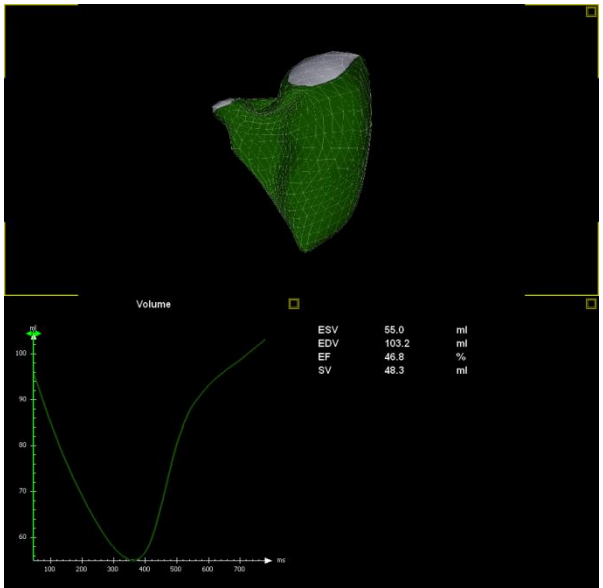
Evaluation VD

- **Analyse du strain**

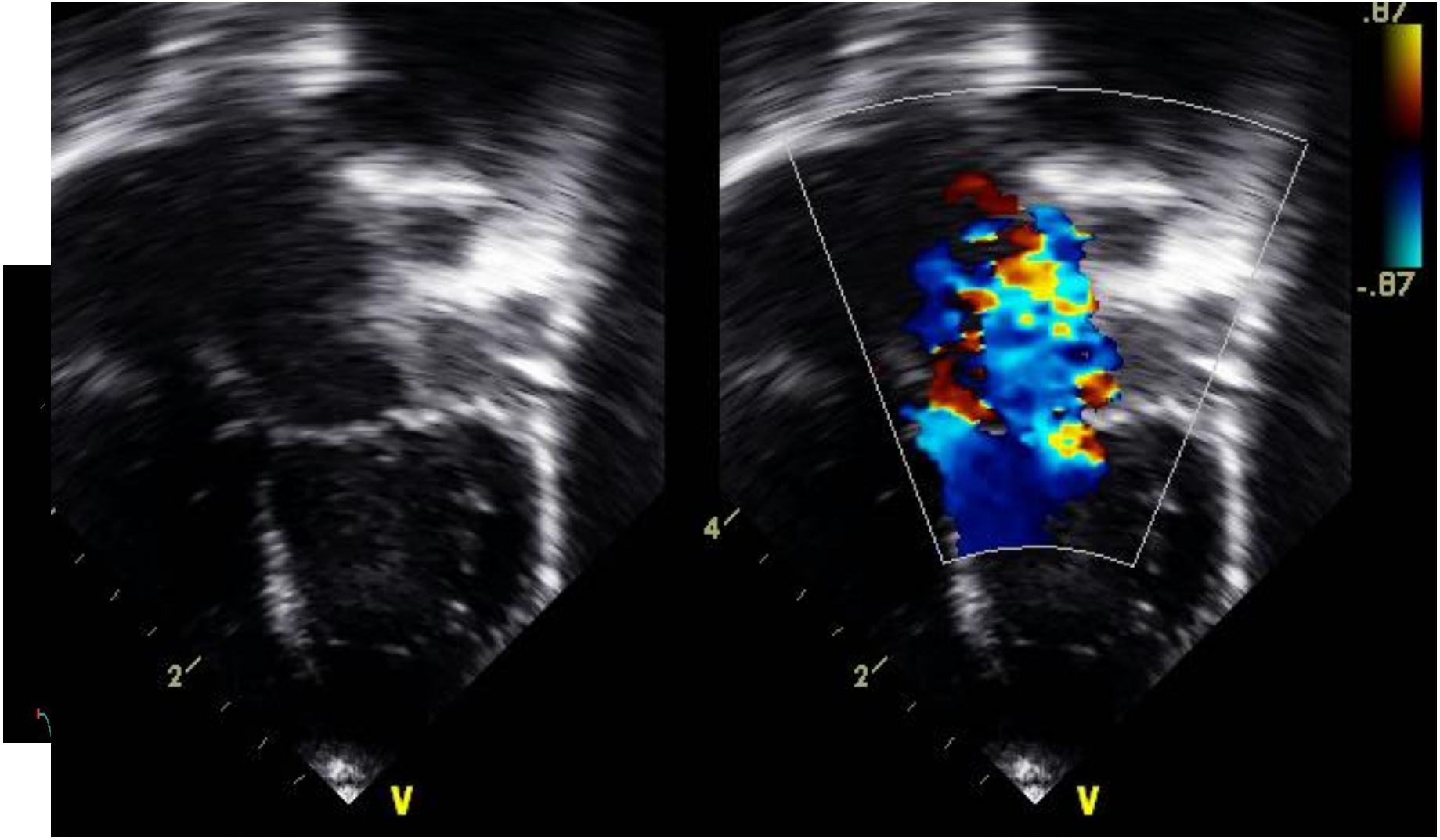


- **Echo 3D**

- Analyse des volumes et de la fonction



Echocardiographie pré-opératoire



Echocardiographie pré-opératoire

- **Recherche systématique d'un shunt G-D +++**

⇨ Indispensable pour chirurgie à cœur battant (valvulation pulmonaire)

⇨ Gène le geste chirurgical

- CA
- CIV
- Fistule systémico-pulmonaire
- MAPCA's

Petite vérification de dernière minute: rarement inutile!

- CIV: topographie exacte, éléments associés(SPI, ALCAPA)
- CIA: retour veineux pulmonaire, VCSG
- TGV: position des coronaires, masse VG
- Fallot: Ø anneau et branches, coronaires
- CoA: Ø des segments de l’aorte, crosse
- CAV: taille ventricules, piliers
- Anastomoses: crosse à droite

Echocardiographie per-opératoire

- **Stratégie à déterminer avant !!!**

- ETO / Echo épicardique
- Mise en place de la sonde en début d'intervention

- **Dernière vérification avant le geste chirurgical**

- **Analyse une fois la CEC posée**

⇨ Évaluation de la réparation
⇨ Évaluation des fonctions ventriculaires
⇨ Évaluation du remplissage

Echocardiographie per-opératoire

- **Impact de l'ETO**

Intraoperative transesophageal echocardiography during surgery for congenital heart defects

Randolph et al. J Thorac Cardiovasc Surg 2002;124: 1176-82

1002 patients

TABLE 6. Major impact by primary diagnosis (either before or after bypass)

Primary diagnosis	Patients (No.)	Impact (%)	Odds ratio
Complex right ventricular outflow tract obstruction	23	47.8	6.040
Double-outlet right ventricle	29	31.0	2.892
Transposition of the great arteries with or without VSD	44	27.3	2.432
Complex atrioventricular discordance	33	24.2	2.029
Subaortic stenosis	57	21.1	1.702
Partial atrioventricular canal	55	20.0	1.585

Echocardiographie per-opératoire

- **Impact de l'ETO**

Intraoperative transesophageal echocardiography during surgery for congenital heart defects

Randolph et al. J Thorac Cardiovasc Surg 2002;124: 1176-82

1002 patients

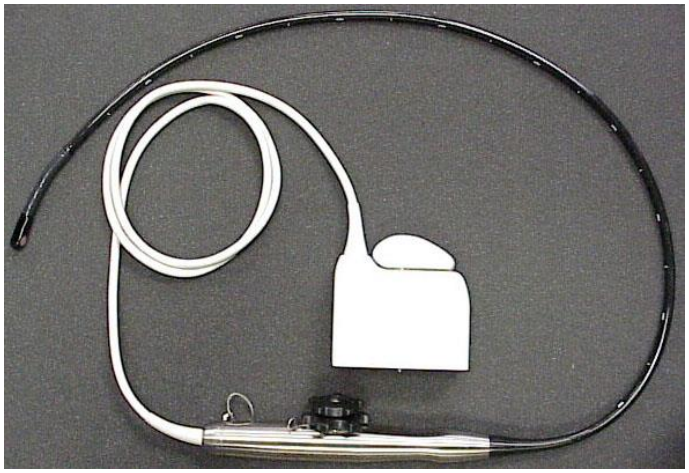
TABLE 3. Major impact by age (either before or after bypass)

Age (y)	Total patients	Major impact No.	Major impact %
<6	377	59	15.6
≥6 to <18	289	44	15.2
≥18	336	37	11.0*

*P = .018 versus patients younger than 18 years at the time of the operation.

Echocardiographie per-opératoire

- **Matériel: selon le poids…**



S7-2

S8-3t

Echocardiographie per-opératoire

- **Sonde mini-multi: à partir de 3kg**

Safety and efficiency of the new micro-multiplane transoesophageal probe in paediatric cardiology

Sébastien Hascoët[a,1], Marianne Peyre[a,1], Khaled Hadeed[a], Xavier Alacoque[b], Gérald Chausseray[b], Rose Fesseau[b], Romain Amadieu[a], Bertrand Léobon[c], Lionel Berthomieu[d], Yves Dulac[a], Philippe Acar[a,*]

Table 3 Insertion, handling and image quality results.

Score	Insertion	Handling	2-dimensional	Colour	Pulsed	Continuous
< 7 kg (n = 9 [23.7%])						
1	9 (100)	5 (55.6)	5 (55.6)	9 (100)	7 (77.7)	8 (88.9)
2	–	4 (44.4)	4 (44.4)	–	–	1 (11.1)
3	–	–	–	–	2 (22.2)	–
4	–	–	–	–	–	–
7–11.9 kg (n = 10 [26.3%])						
1	10 (100)	1 (10.0)	5 (50.0)	7 (70.0)	4 (40.0)	5 (50.0)
2	–	7 (70.0)	4 (40.0)	3 (30.0)	6 (60.0)	5 (50.0)
3	–	2 (20.0)	1 (10.0)	–	–	–
4	–	–	–	–	–	–
12–17 kg (n = 10 [26.3%])						
1	9 (90.0)	–	3 (30.0)	6 (60.0)	5 (50.0)	6 (60.0)
2	–	3 (30.0)	6 (60.0)	4 (40.0)	3 (30.0)	4 (40.0)
3	1 (10.0)	6 (60.0)	1 (10.0)	–	2 (20.0)	–
4	–	1 (10.0)	–	–	–	–
> 17 kg (n = 9 [23.7%])						
1	9 (100)	–	3 (33.3)	4 (44.4)	5 (55.6)	4 (44.4)
2	–	4 (44.4)	5 (55.6)	5 (55.6)	3 (33.3)	5 (55.6)
3	–	4 (44.4)	1 (11.1)	–	1 (11.1)	–
4	–	1 (11.1)	–	–	–	–
P^a	1.0	0.006	0.91	0.07	0.12	0.23

[a] Exact Fischer test was used to assess the relationship between each echographic parameter and the weight quartiles.

Archives of Cardiovascular Disease (2014) 107, 361–370

Echocardiographie per-opératoire

- **Echo épicardique: une alternative**

The impact of additional epicardial imaging to transesophageal echocardiography on intraoperative detection of residual lesions in congenital heart surgery

Andreea Dragulescu, MD, PhD,[a] Fraser Golding, MD,[a] Glen Van Arsdell, MD,[a]
Christopher Caldarone, MD,[a] Luc Mertens, MD, PhD,[a] Osman Al-Radi, MD,[b,c] and Kyong-Jin Lee, MD[a]

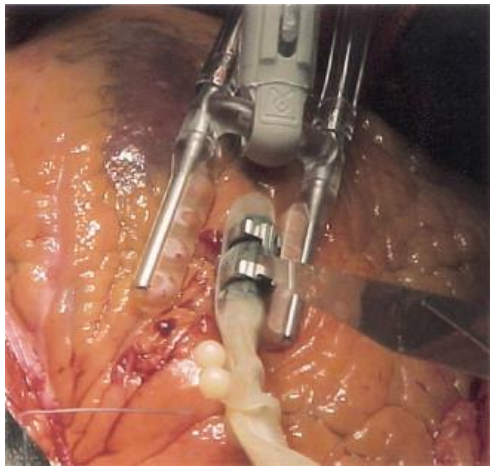


TABLE 1. Indications for surgical revisions

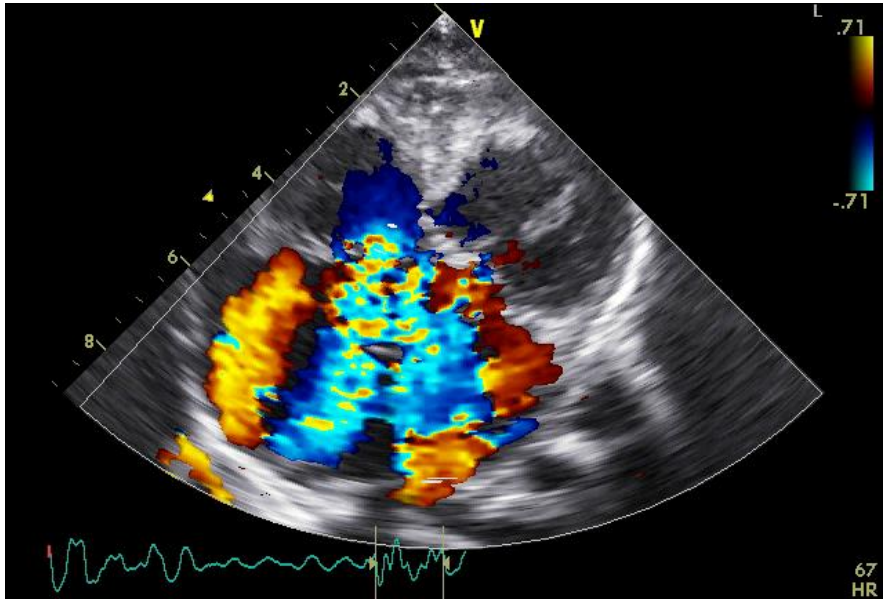
Indications for surgical revisions	TEE alone (n = 1109)	EpE (n = 95)	
		EpE alone	TEE + EpE
Right ventricular outflow tract	36	1	–
Atrioventricular valve	29	1	1*
Coronary arteries	12	–	3
Venoatrial connections/baffles (including pulmonary veins)	10	–	1
Ventricular septal defect	8	–	–
Pulmonary arteries	7	–	5
Left ventricular outflow tract	6	–	–
Aortic arch/ Blalock–Taussig shunt	1	–	2
Total	109 (9.8%)	2 (5.3%)	12 (21.1%)†

*In 1 patient the indication for atrioventricular valve revision was made by TEE; EpE also was performed to evaluate Glenn anastomosis. †$P = .02$ compared with TEE alone.

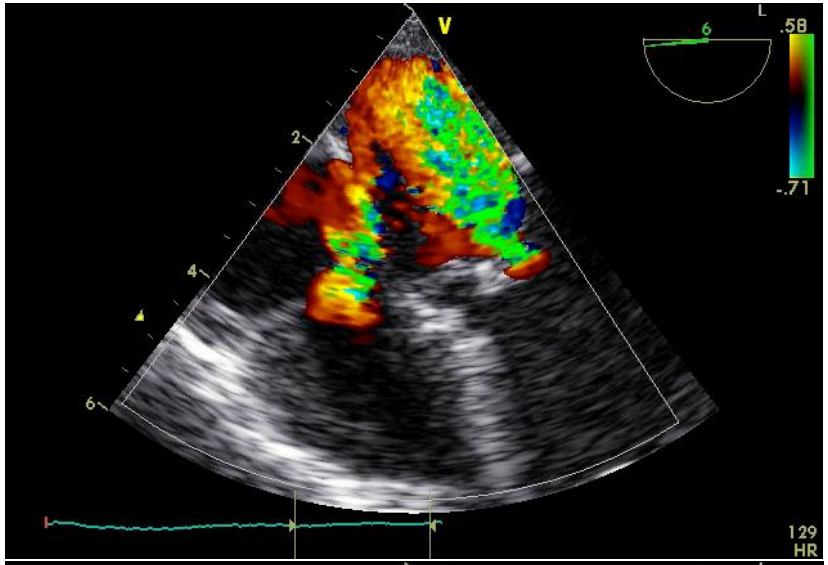
The Journal of Thoracic and Cardiovascular Surgery 2012

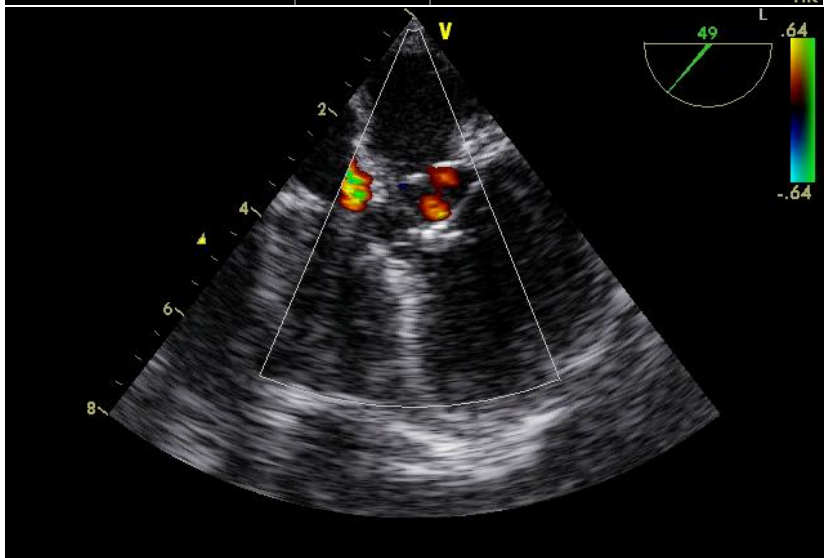
Echocardiographie per-opératoire

- **Evaluation de la qualité de la réparation**



CAV complet

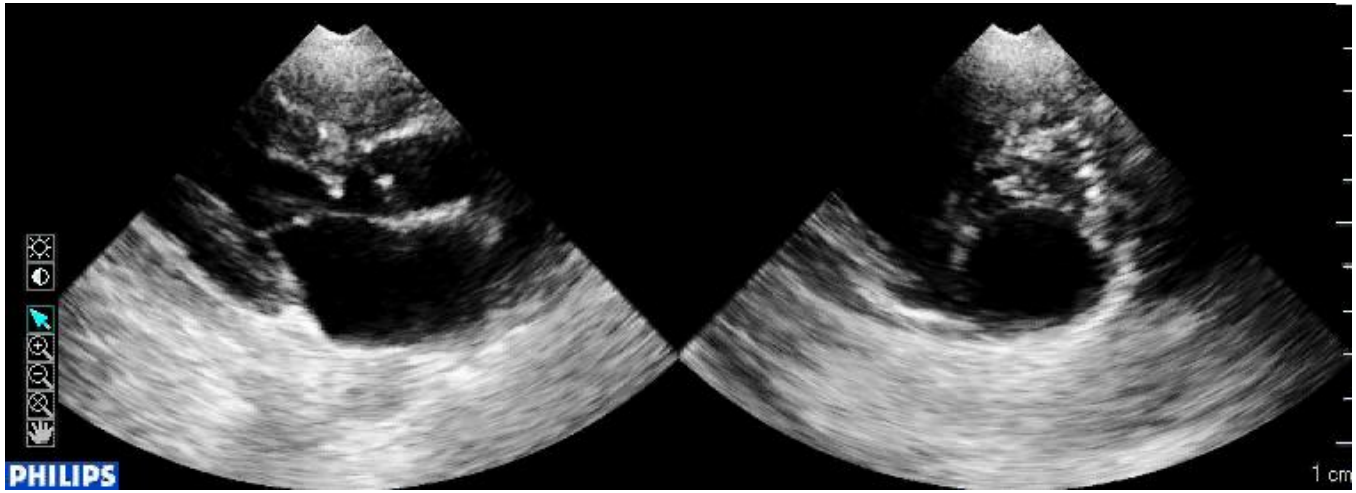


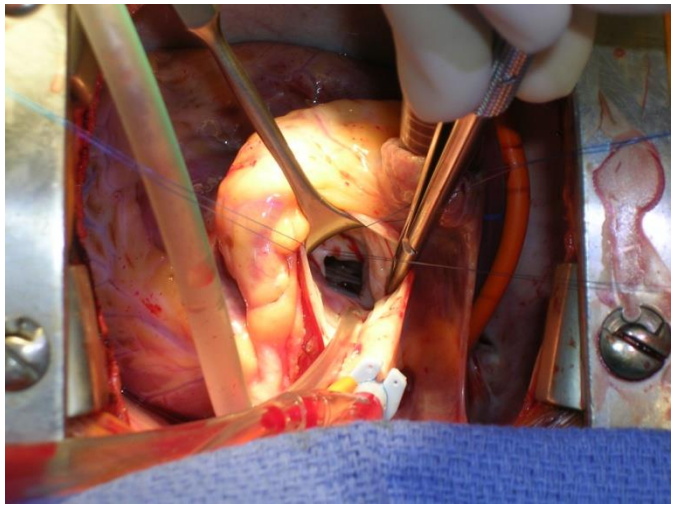


Echocardiographie per-opératoire

- **Evaluation de la qualité de la réparation**

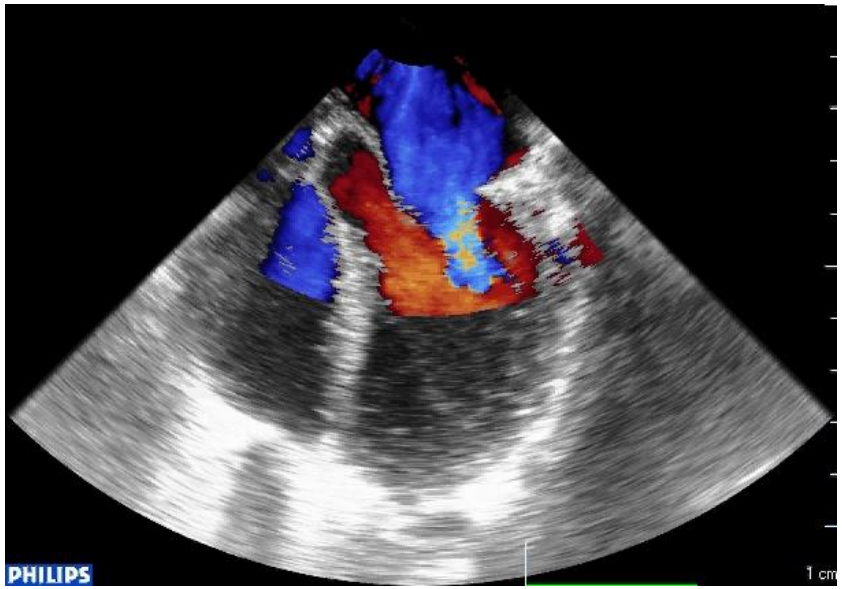
Membrane sous-aortique

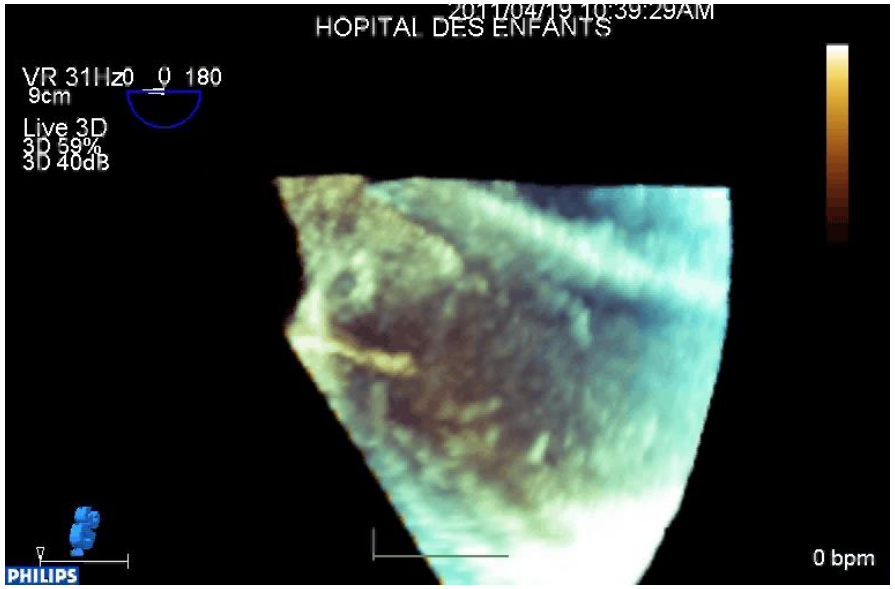


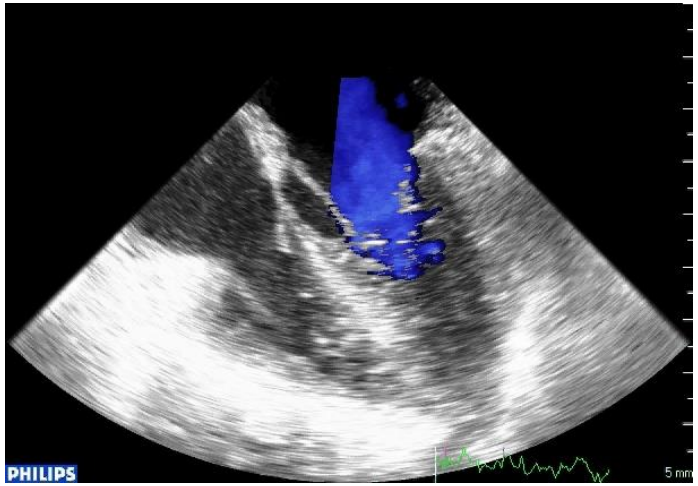


Echocardiographie per-opératoire

- **Evaluation de la qualité de la réparation**







Echocardiographie post-opératoire

- **Difficultés**

  - accessibilité

  - thorax ouvert

  - pansements

  - ventilation

Echocardiographie post-opératoire

- **Evaluation anatomique**

  - qualité de la réparation

  - lésions résiduelles

- **Evaluation hémodynamique**

  - fonction VG et VD

  - volémie

  - pressions pulmonaires

  - Qp/Qs

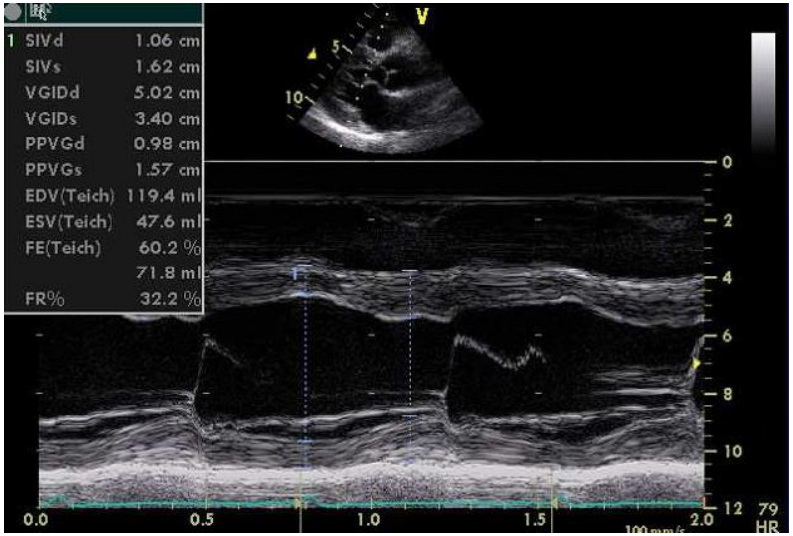
  - péricarde

Echocardiographie post-opératoire

- **Fonction VG mode TM**

A partir de la formule de Teicholz (volumes extrapolés des diamètres)

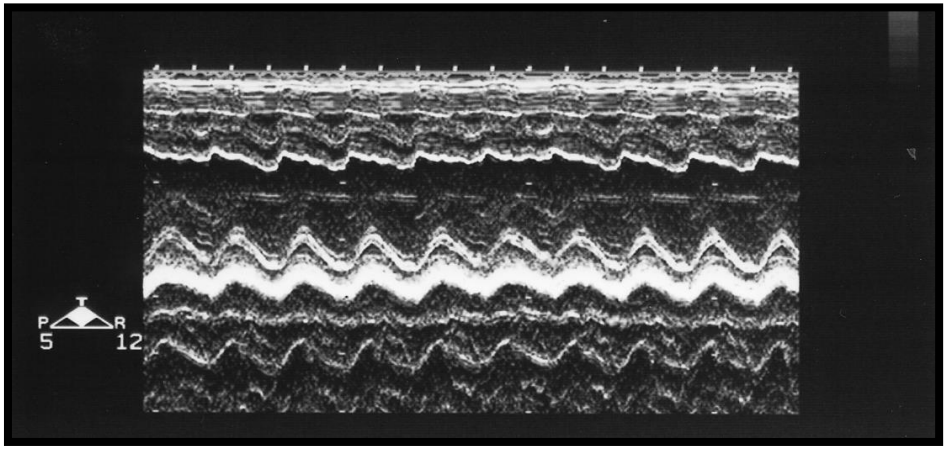
$$FE = \frac{VTD - VTS}{VTD}$$



Limites:

- Septum paradoxal

- Interaction VG-VD



Echocardiographie post-opératoire

- **Fonction VG méthode de Simpson**

Limites: - visualisation de l'endocarde

- dysfonction régionale non concernée par les plans de coupe

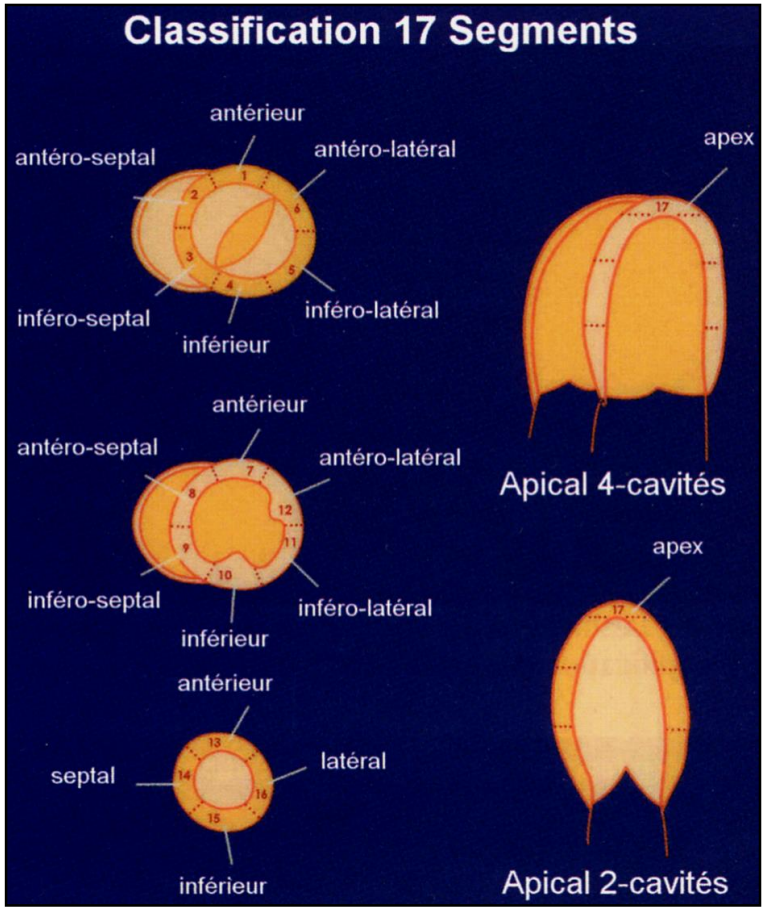
- **Estimation visuelle**

Fiable si opérateur expérimenté

Parfois la seule méthode possible

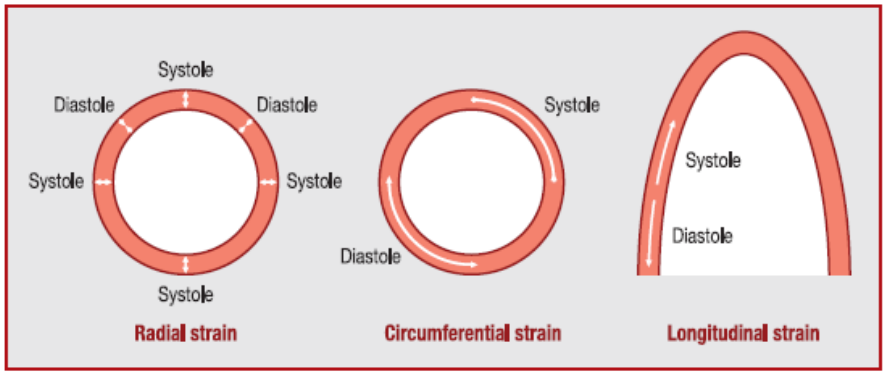
Echocardiographie post-opératoire

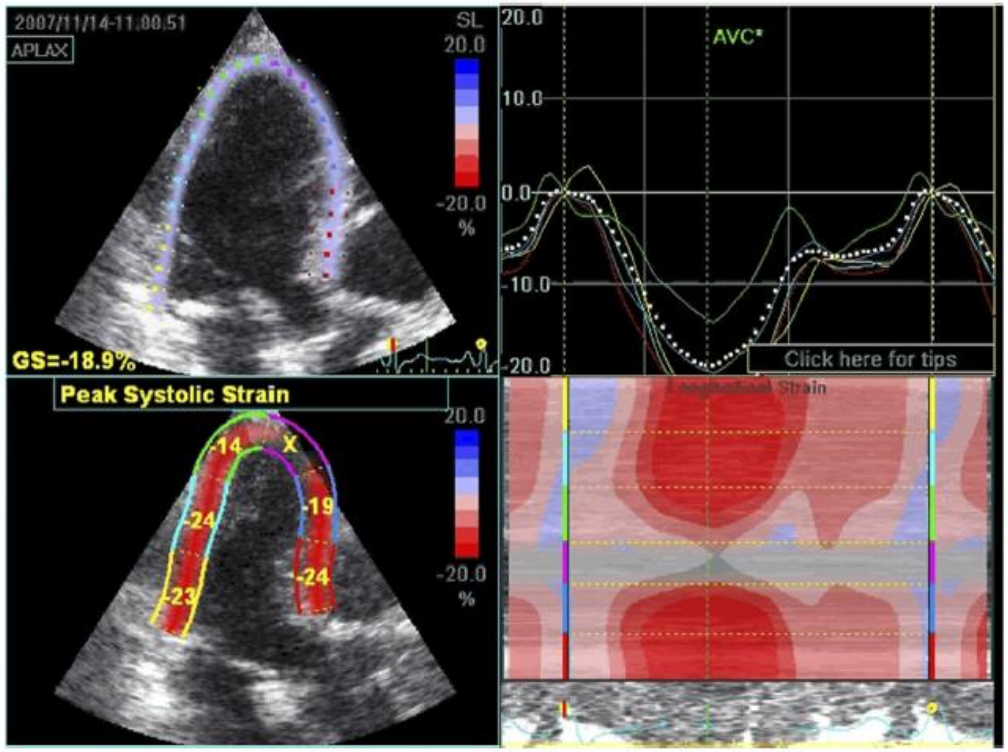
- **Analyse de la cinétique segmentaire**



Echocardiographie post-opératoire

- **Intérêt de l'analyse du strain ?**





Echocardiographie post-opératoire

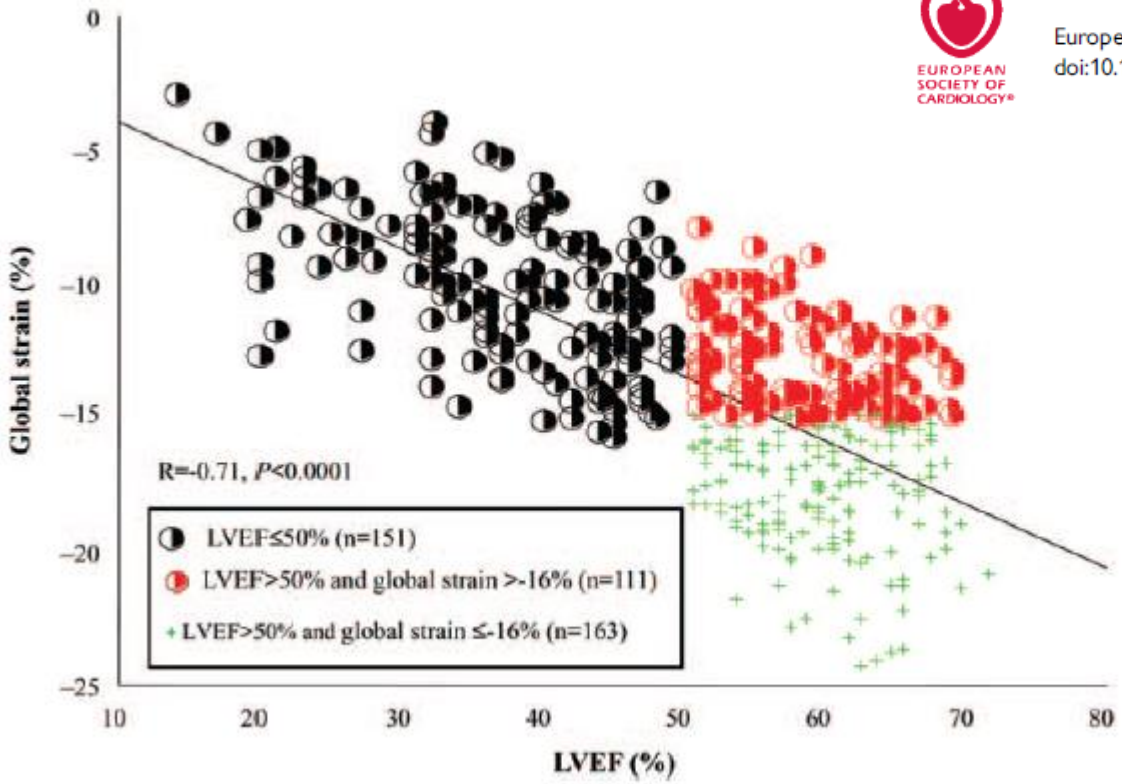
- **Intérêt de l'analyse du strain ?**

- 425 adultes
- Analyse pré-op du strain

Incremental value of global longitudinal strain for predicting early outcome after cardiac surgery

Julien Ternacle[1†], Matthieu Berry[2†], Enrique Alonso[1], Martin Kloeckner[1], Jean-Paul Couetil[1], Jean-Luc Dubois Randé[1], Pascal Gueret[1], Jean-Luc Monin[1], and Pascal Lim[1*]

European Heart Journal – Cardiovascular Imaging
doi:10.1093/ehjci/jes156



Echocardiographie post-opératoire

- **Intérêt de l'analyse du strain ?**

Incremental value of global longitudinal strain for predicting early outcome after cardiac surgery

Julien Ternacle[1†], Matthieu Berry[2†], Enrique Alonso[1], Martin Kloeckner[1], Jean-Paul Couetil[1], Jean-Luc Dubois Randé[1], Pascal Gueret[1], Jean-Luc Monin[1], and Pascal Lim[1*]

EUROPEAN SOCIETY OF CARDIOLOGY®
European Heart Journal – Cardiovascular Imaging
doi:10.1093/ehjci/jes156

Table 4 Independent predictors of post-operative outcome with EuroSCORE II

	OR	95% CI	*P*-value
Inotrope support >48 h			
Global strain (per %)	1.15	1.08–1.21	<0.001
CPB duration (per 30 min)	1.23	1.12–1.35	<0.001
EuroSCORE (per %)	1.07	1.02–1.11	0.002
Mortality			
Global strain (per %)	1.10	1.01–1.21	0.03
CPB duration (per 30 min)	1.17	1.04–1.32	0.009
EuroSCORE (per %)	1.07	1.03–1.11	0.001
Mortality + inotrope support >48 h			
Global strain (per %)	1.15	1.09–1.21	<0.001
CPB duration (per 30 min)	1.26	1.14–1.39	<0.001
EuroSCORE II (per %)	1.07	1.02–1.12	0.002

OR, odds ratio; CI, confidence interval.

⇨ Strain longitudinal pré-op altéré

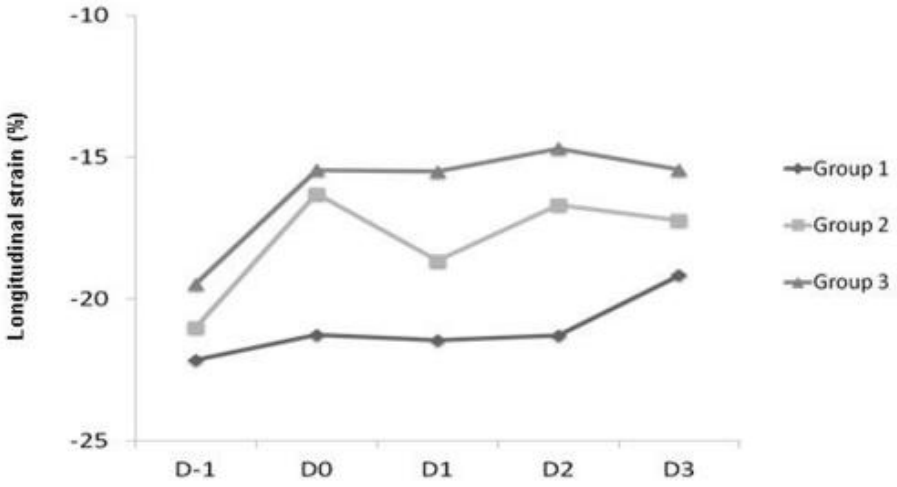
= surmortalité

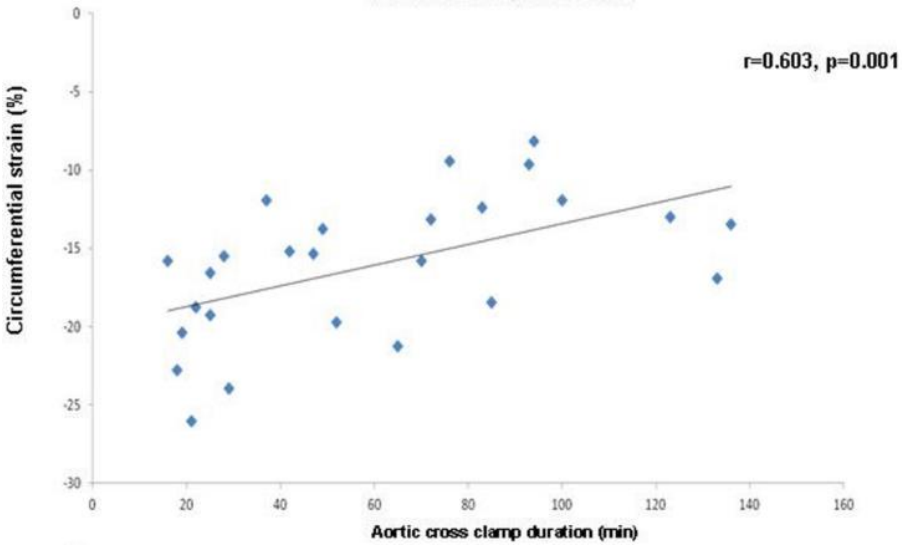
Echocardiographie post-opératoire

- **Intérêt de l'analyse du strain ?**

- 33 enfants
- 3 groupes selon durée de CEC (<30min, 30-80min, >80min)

- Faisabilité excellente
- Reproductibilité très bonne



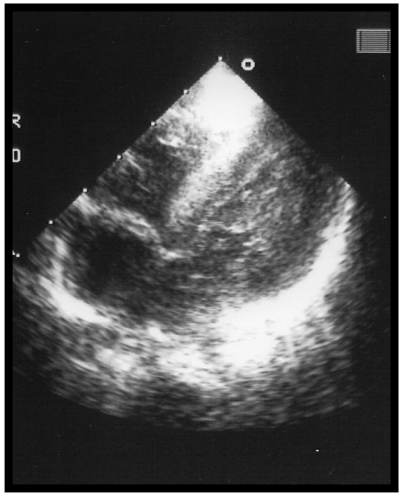


Perdreau et al. In Press 2016.

Echocardiographie post-opératoire

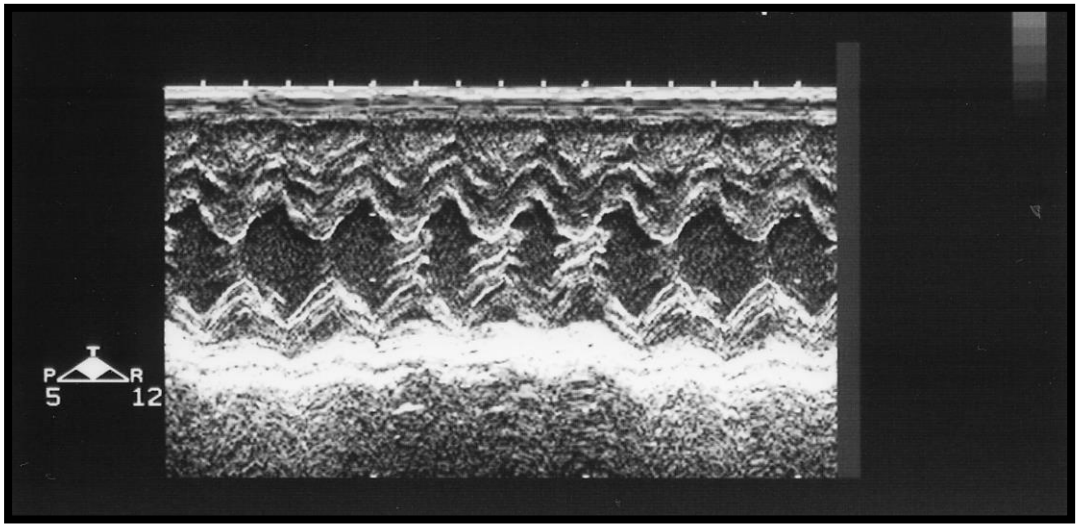
- **Estimation de la volémie**

- Mode bidimensionnel



- Mode TM

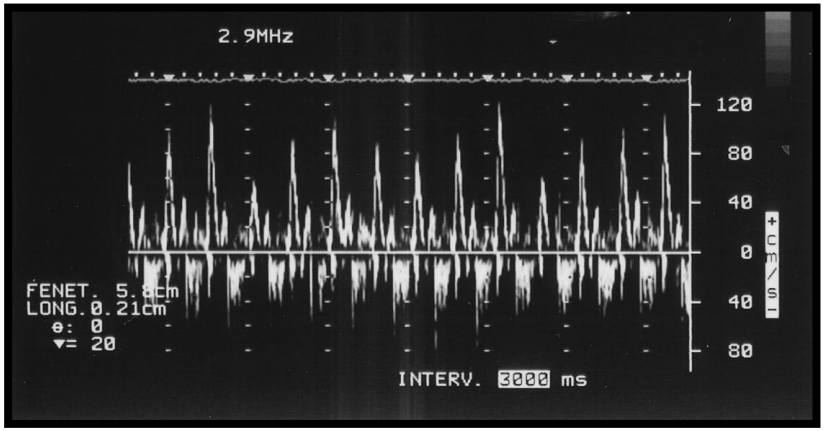
Hyperkinésie
Tachycardie



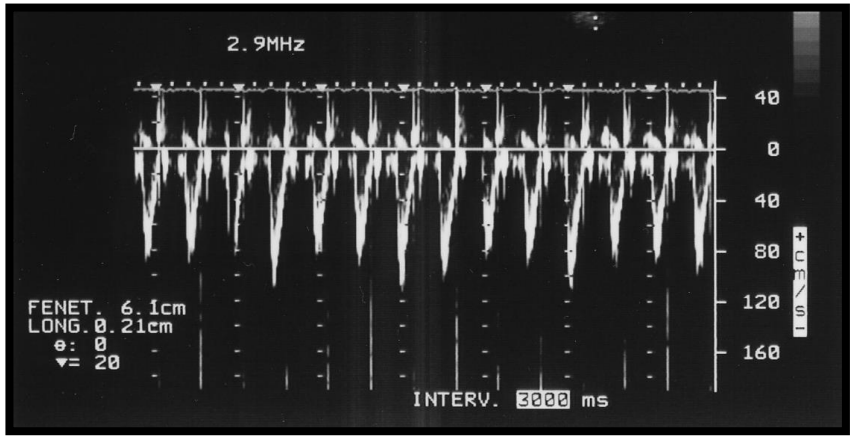
Echocardiographie post-opératoire

- **Estimation de la volémie**

- Mode Doppler: variation respiratoire des flux



Flux trans-mitral

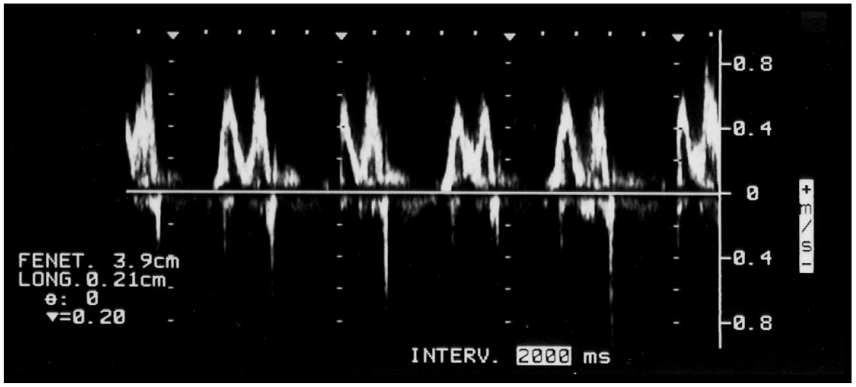


Flux trans-aortique

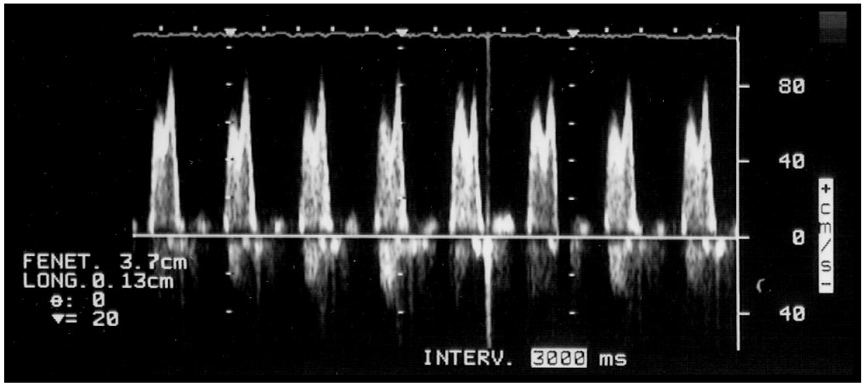
Echocardiographie post-opératoire

- **Estimation de la volémie**

- Mode Doppler: flux trans-mitral modifié



Normovolémie



Hypovolémie:

E<A

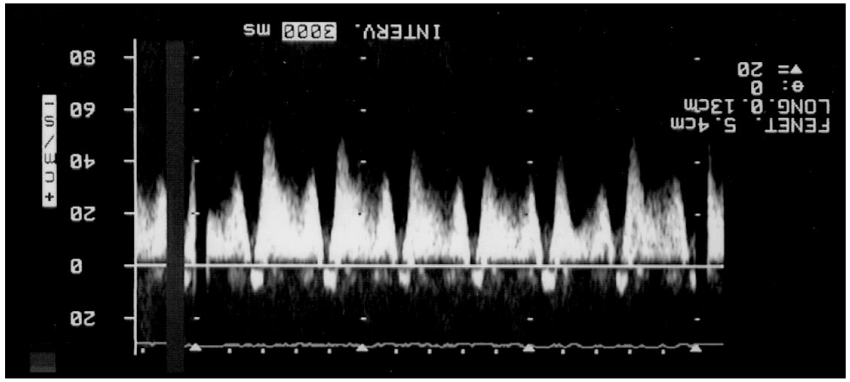
Et à cause de la tachycardie:

Fusion E et A

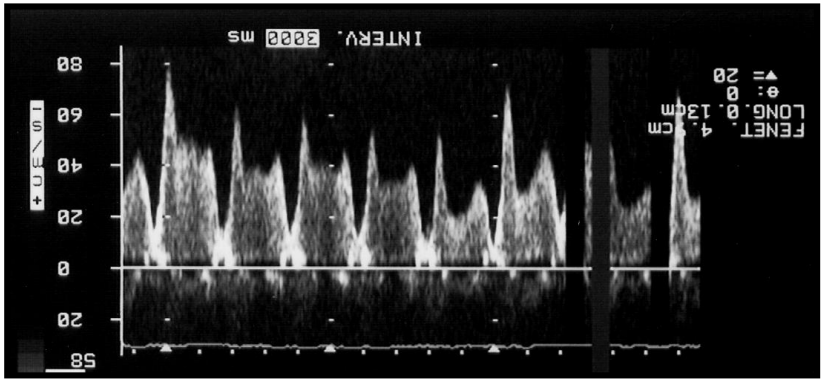
Echocardiographie post-opératoire

- **Estimation de la volémie**

- Mode Doppler: flux veineux pulmonaire modifié



Normovolémie



Hypovolémie:

POG basse ⇨ onde S↗

S >> D

Echocardiographie post-opératoire

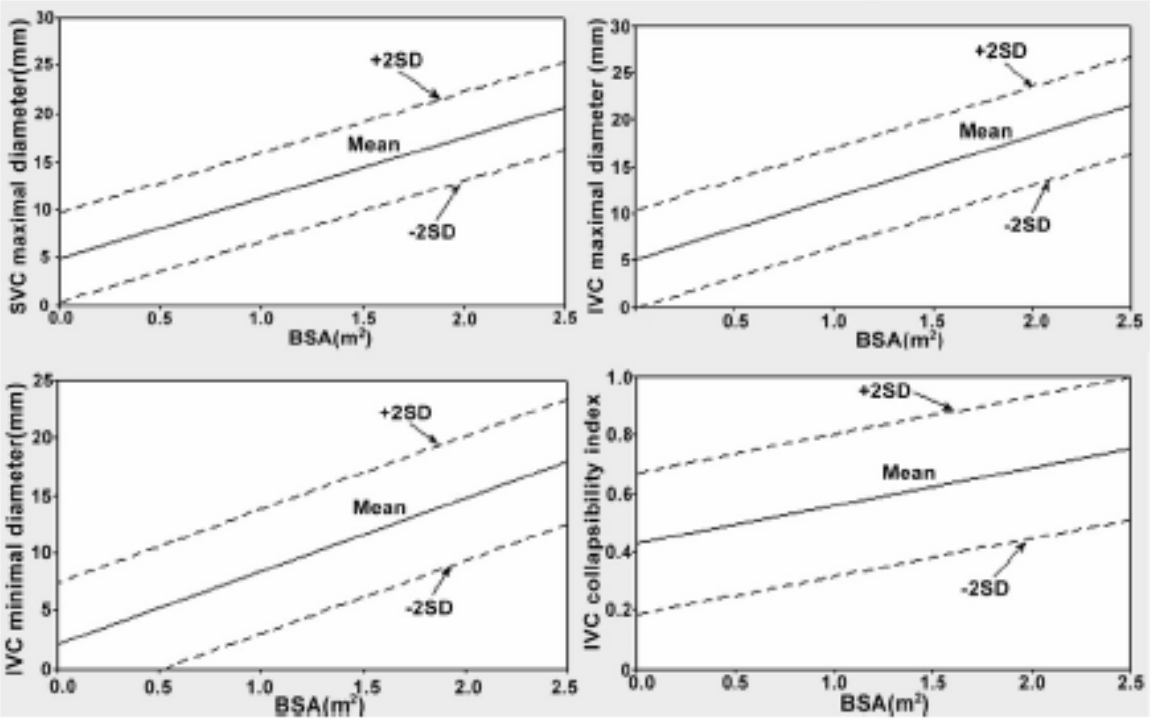
- **Estimation de la volémie**

- Diamètre de la VCI

Systemic Venous Diameters, Collapsibility Indices, and Right Atrial Measurements in Normal Pediatric Subjects

Shelby Kutty, MD, FASE, Ling Li, MD, PhD, RDMS, Rimsha Hasan, MD, Qinghai Peng, MD, PhD, Sheela Rangamani, MD, and David A. Danford, MD, *Omaha, Nebraska*

(J Am Soc Echocardiogr 2014;27:155-62.)



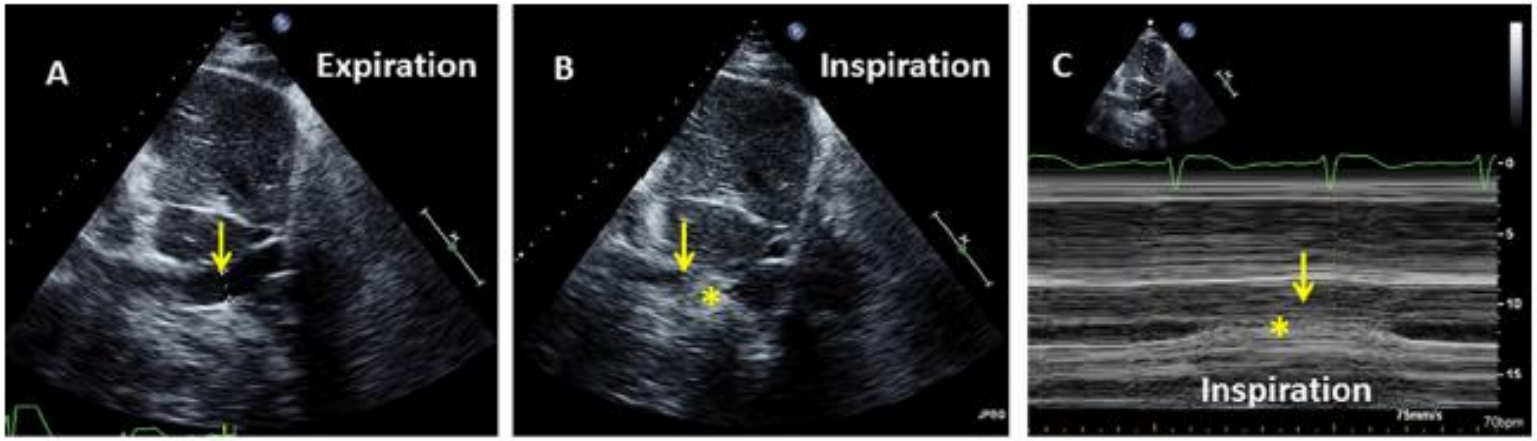
Echocardiographie post-opératoire

- **Estimation de la volémie**

- Diamètre de la VCI

Patient en VS: inspiration (pression négative) = collapsus

Patient intubé: inspiration (pression positive) = pas de collapsus



Echocardiographie post-opératoire

- **Estimation de la volémie**

- Diamètre de la VCI

Inferior Vena Cava Diameter and Central Venous Pressure Correlation During Cardiac Surgery

Suraphong Lorsomradee, MD, Sratwadee Lorsomradee, MD, Stefanie Cromheecke, MD, Pieter W. ten Broecke, MD, and Stefan G. De Hert, MD, PhD

Journal of Cardiothoracic and Vascular Anesthesia, Vol 21, No 4 (August), 2007: pp 492-496

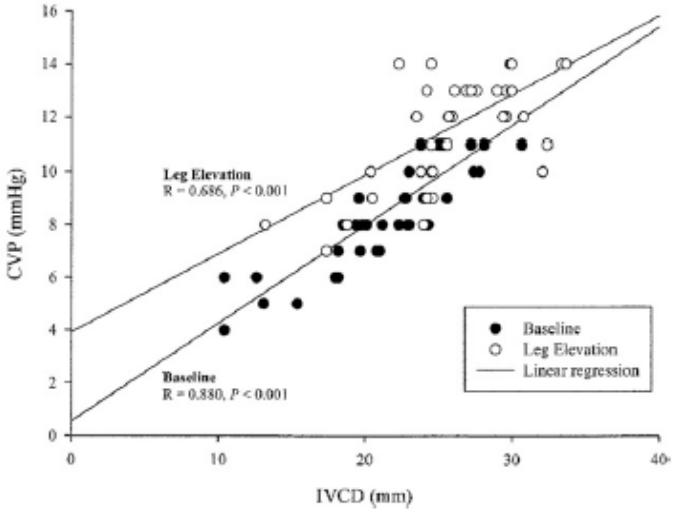


Fig 3. Correlation between the CVP and the IVCD before and after leg elevation in patients with baseline (CVP ≤11 mmHg, $R = 0.880$, $p < 0.001$ [before leg elevation] and $R = 0.686$, $p \leq 0.001$ [after leg elevation]).

Echocardiographie post-opératoire

- **Estimation de la pression OD**

- Rapport E/E' tricuspide

Noninvasive Evaluation of Right Atrial Pressure

Roy Beigel, MD, Bojan Cercek, MD, PhD, Huai Luo, MD, PhD, and Robert J. Siegel, MD, *Los Angeles, California*

(J Am Soc Echocardiogr 2013;26:1033-42.)

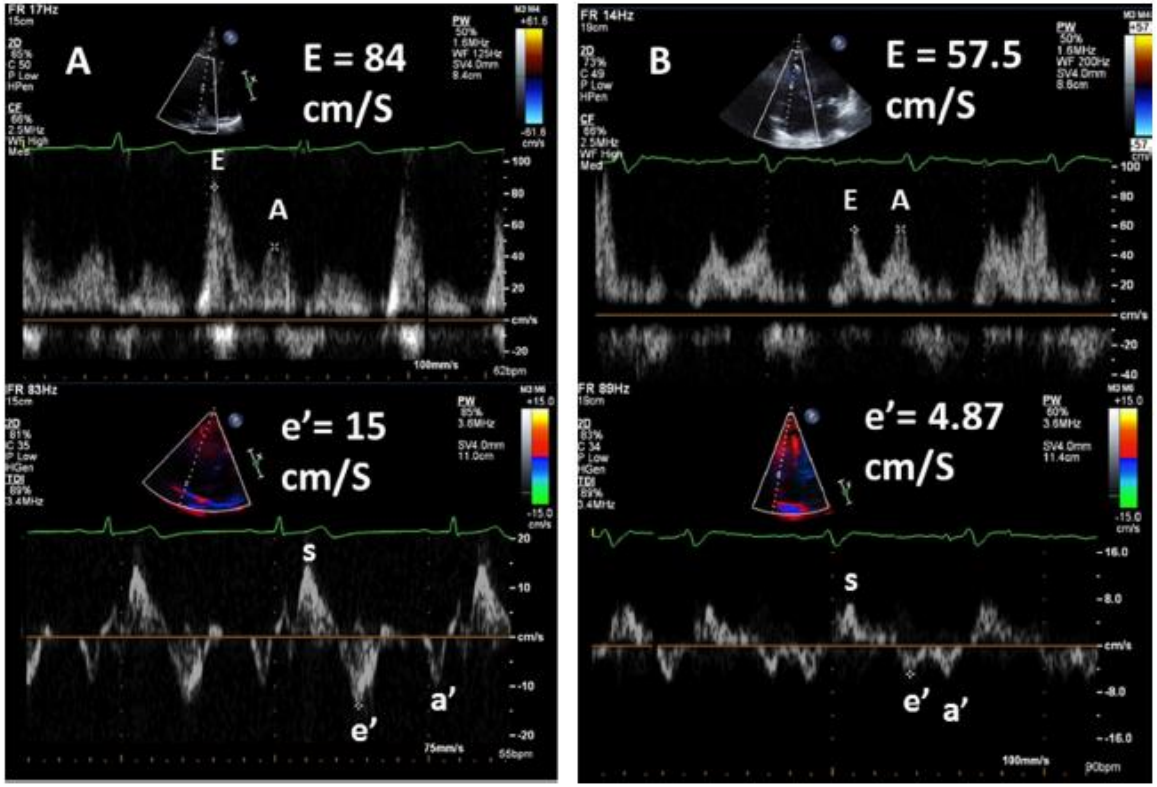


Figure 5 Doppler evaluation of tricuspid inflow. **(A)** (*Top*) Tricuspid inflow velocity Doppler recording (E = 84 cm/sec). (*Bottom*) Tricuspid annular velocity (e') using DTI is 15 cm/sec in a patient with normal RAP. The E/e' ratio is <6. **(B)** (*Top*) Tricuspid inflow velocity Doppler recording (E = 57.5 cm/sec). (*Bottom*) Tricuspid annular velocity (e') is 4.87 cm/sec in a patient with elevated RAP. The E/e' ratio is >6, which suggests an elevated RAP of >10 mm Hg.

Echocardiographie post-opératoire

- **Estimation des pressions pulmonaires**

- Par le flux d'IT

PAPS = (4VmaxIT²) + POD

- Par le flux d'IP

PAPS = (3xPAPm) – (2xPAPd)

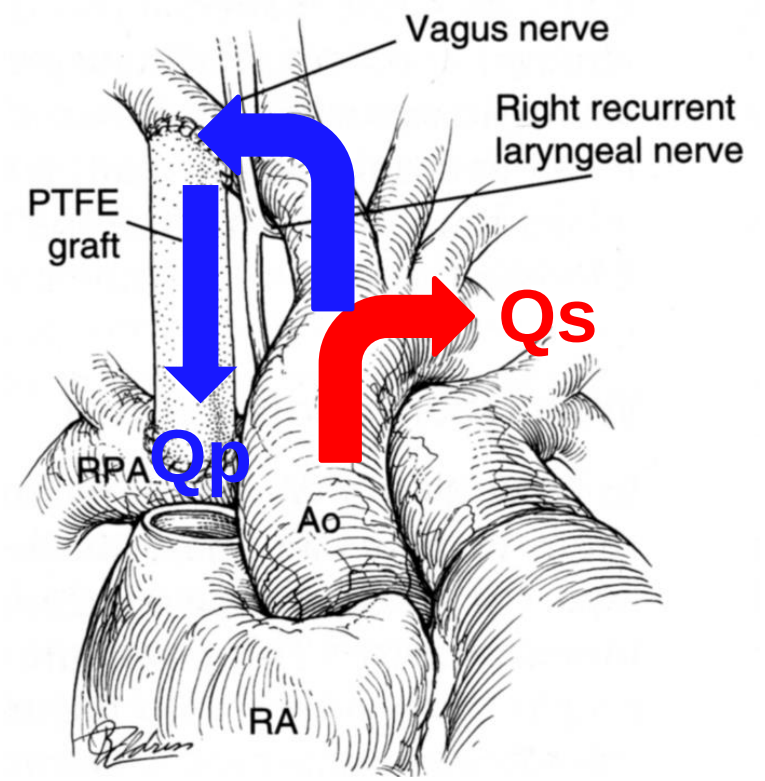
- Par le flux d'une CIV résiduelle

PAPS = PAS – 4VmaxCIV²

- Par la cinétique septale

Echocardiographie post-opératoire

- **Estimation du rapport Qp/Qs: exemple du BT Shunt**



- **Qp >> Qs** = hyperdébit pulmonaire

  ⇨ hypodébit systémique

- **Qp<<Qs** = hypodébit pulmonaire

  ⇨ cyanose

Echocardiographie post-opératoire

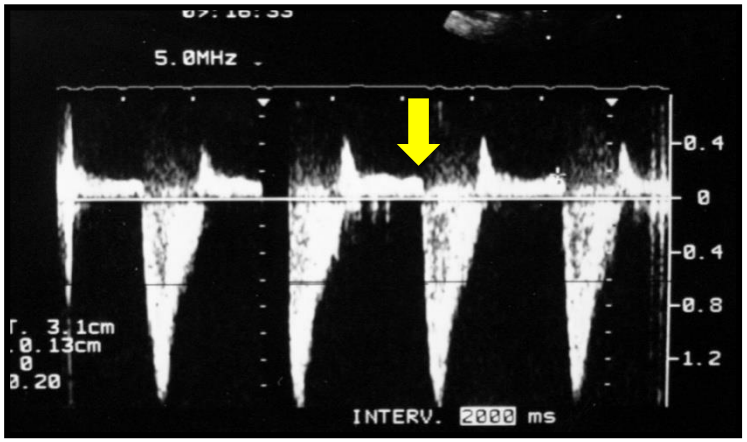
- **Estimation du rapport Qp/Qs: exemple du BT Shunt**

- Qp/Qs = 1

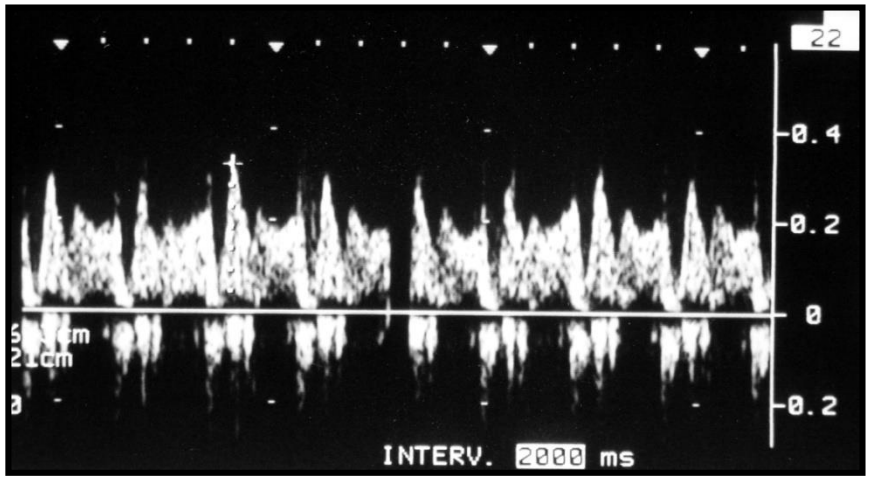
Doppler pulsé isthme aortique

+

Doppler pulsé veines pulmonaires



Vmax TD < 0.2 m/s

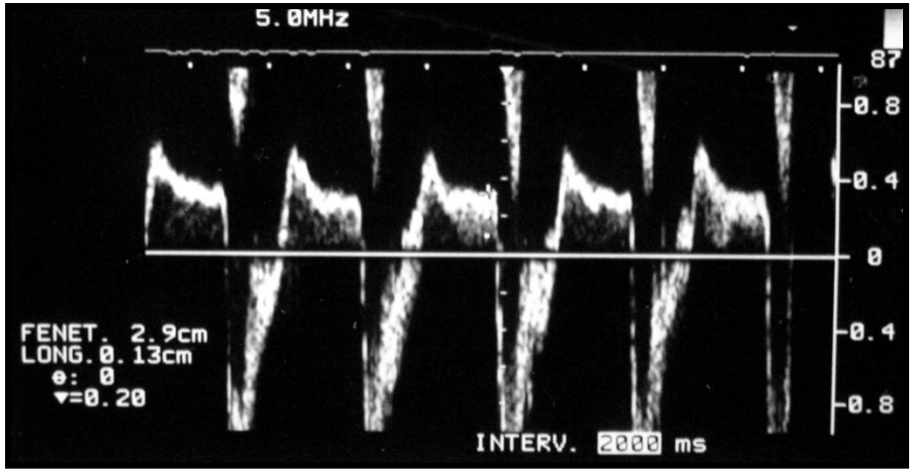


Vmax vp < 1 m/s

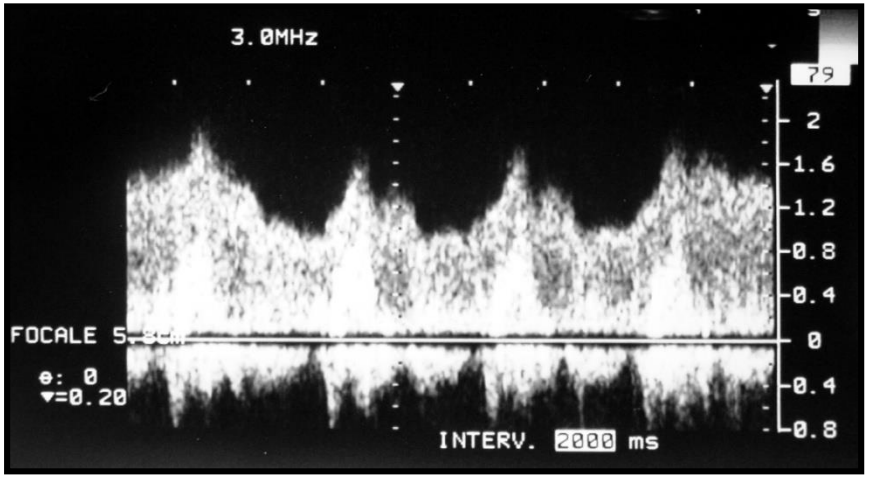
Echocardiographie post-opératoire

- **Estimation du rapport Qp/Qs: exemple du BT Shunt**

- Qp/Qs > 1



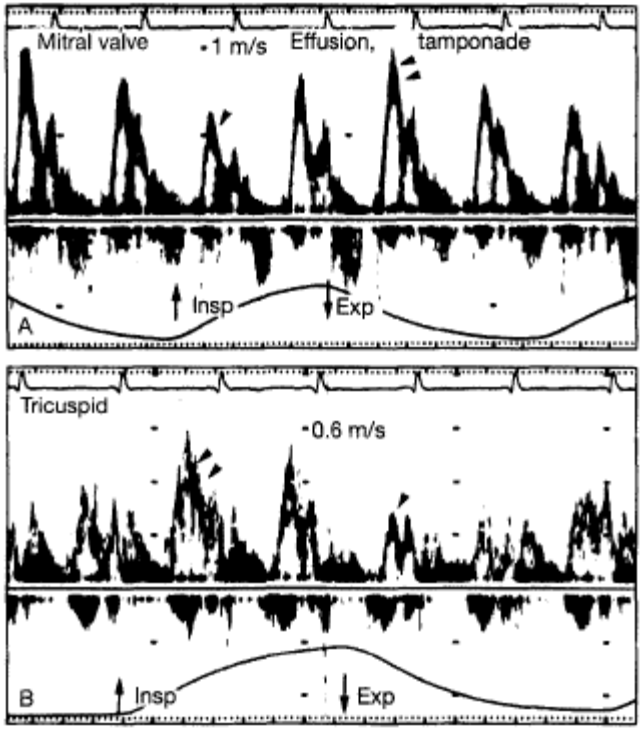
Vmax TD > 0.2 m/s

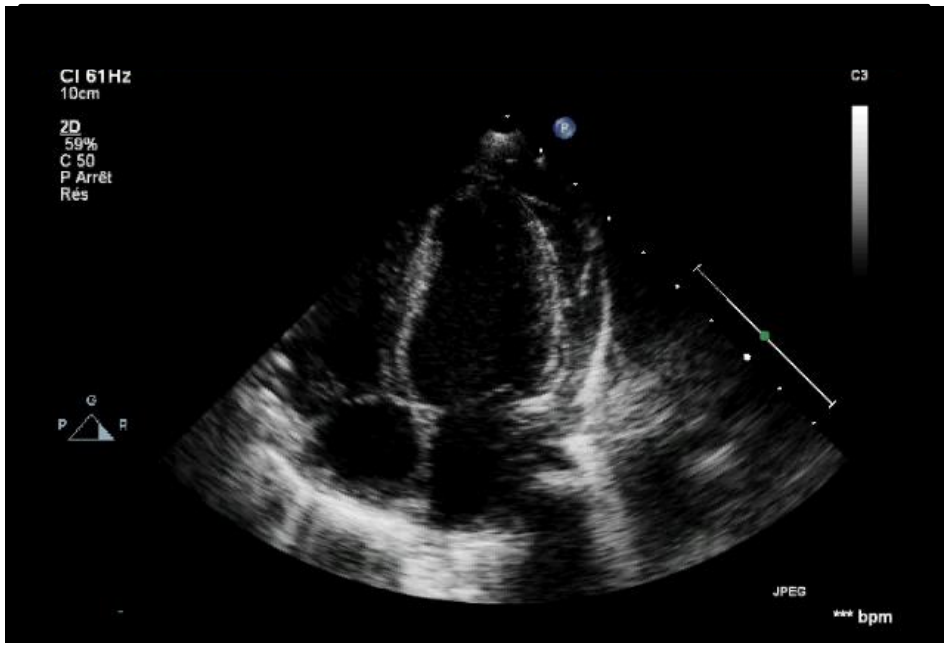


Vmax vp > 1 m/s

Echocardiographie post-opératoire

- **Contrôle du péricarde**





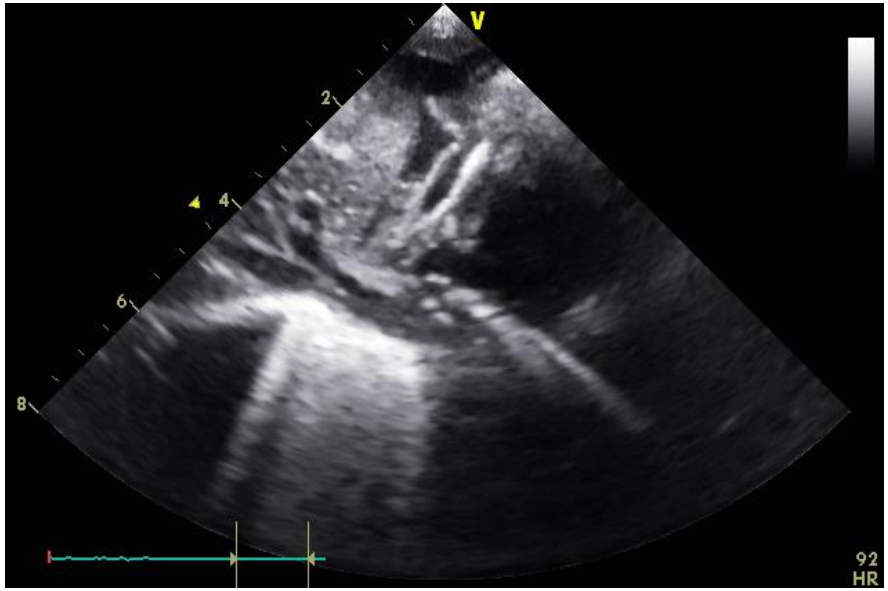
Echocardiographie post-opératoire

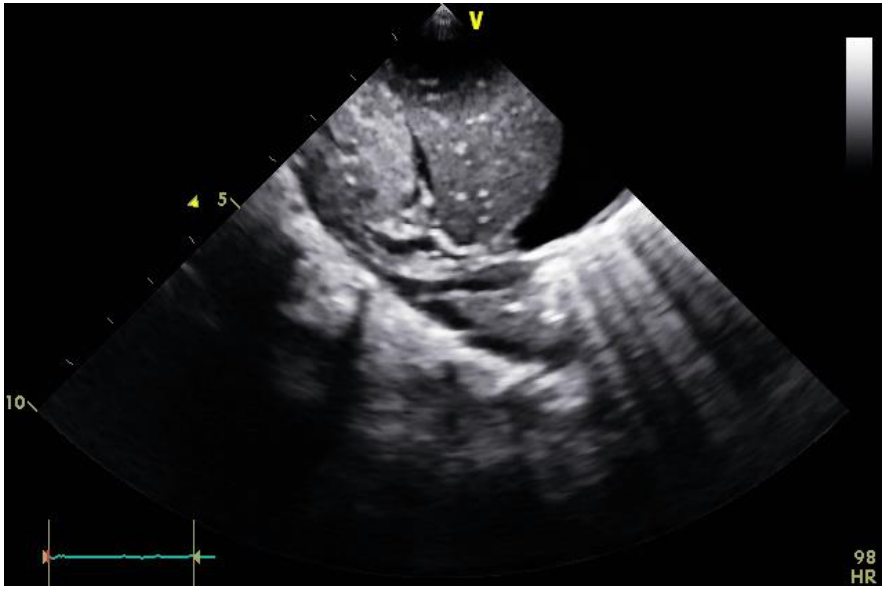
- **Contrôle assistance**

  - position des canules

  - décharge ventriculaire

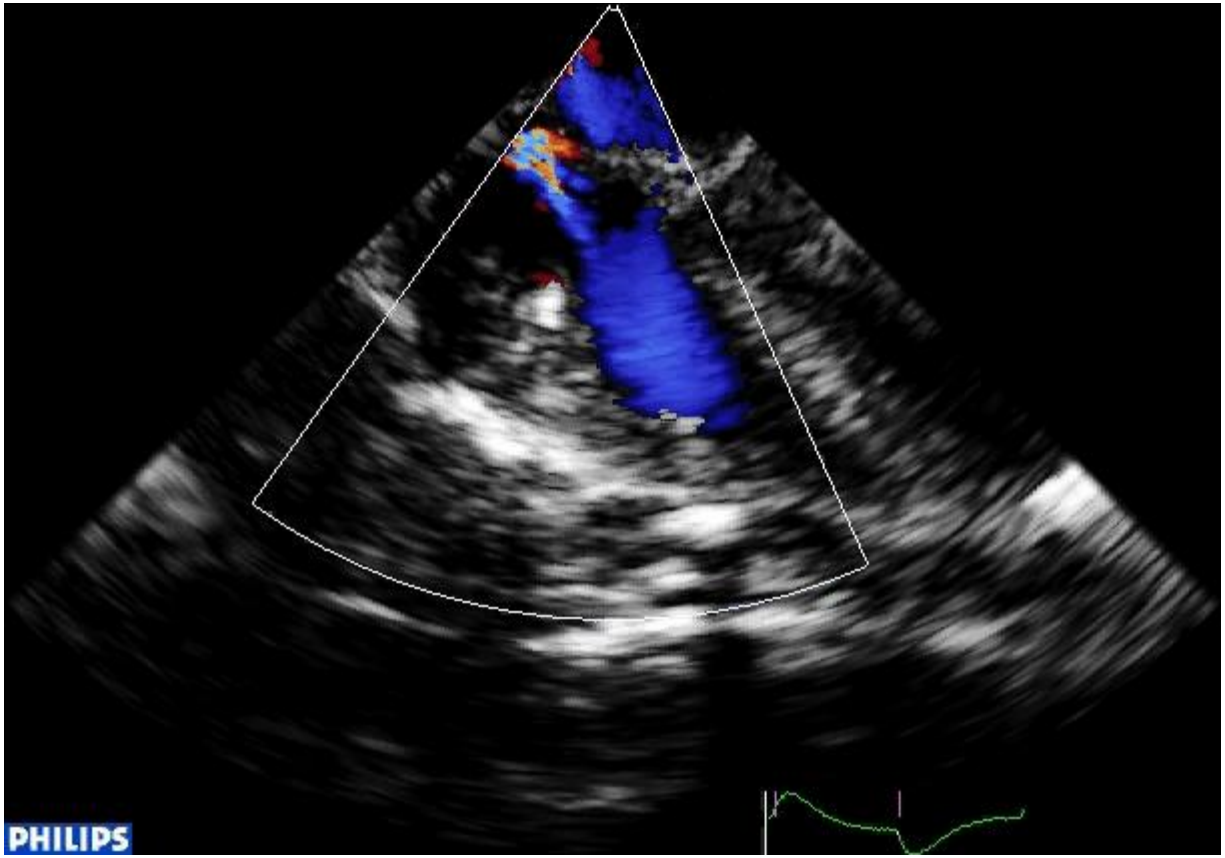
  - récupération du myocarde





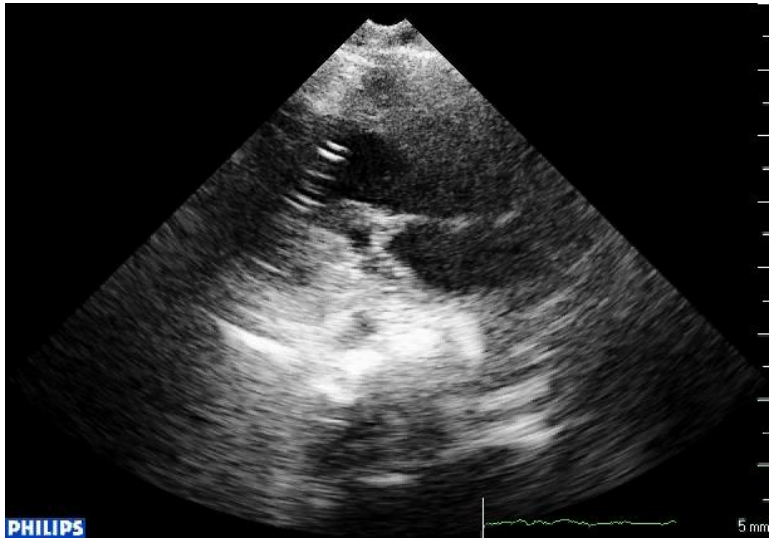
Echocardiographie post-opératoire

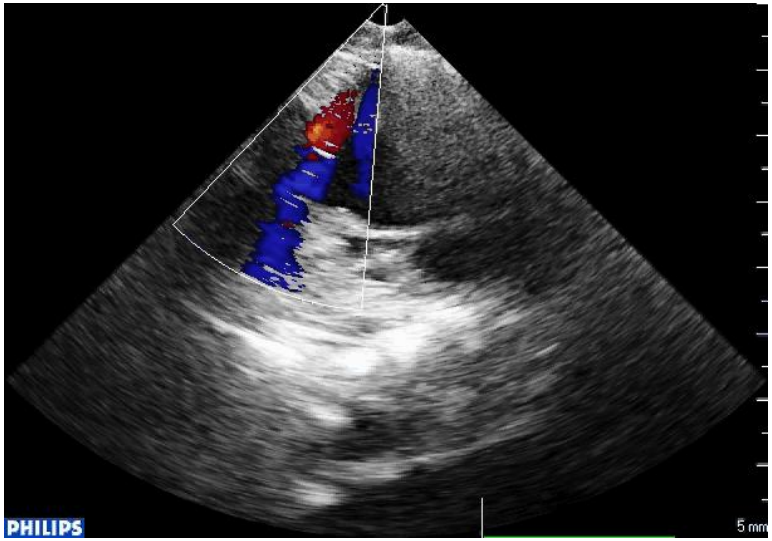
- **Contrôle d'une ECMO veino-veineuse**

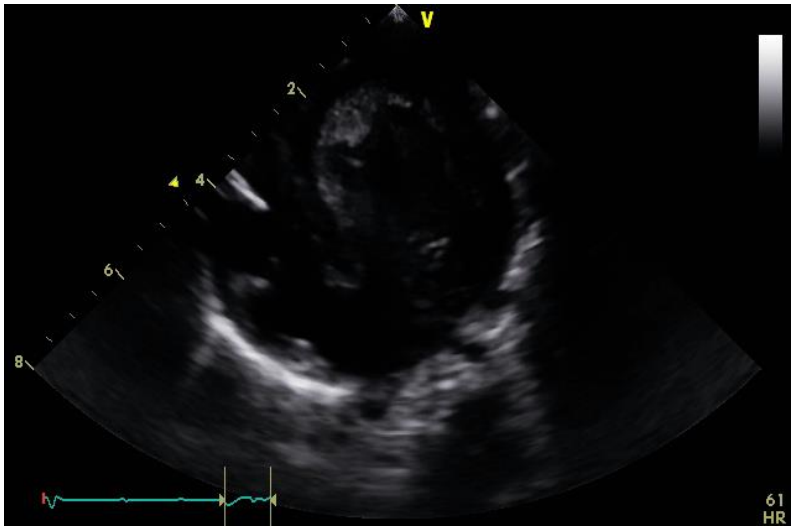


Echocardiographie post-opératoire

- **Contrôle d'un Berlin Heart**







Formation

Guidelines and Standards for Performance of a Pediatric Echocardiogram: A Report from the Task Force of the Pediatric Council of the American Society of Echocardiography

J Am Soc Echocardiogr 2006;19:1413-1430.

Table 3 Training methods recommended for core and advanced levels of expertise

Level of expertise	Recommended methods of training
Core	• Training should take place in a pediatric echocardiography laboratory that serves a hospital with an accredited pediatric cardiology program, inpatient and outpatient facilities, neonatal and pediatric intensive care departments, a pediatric cardiac catheterization laboratory, and a congenital heart surgery program • Supervised performance of at least 150 transthoracic echocardiograms (at least 50 in infants age ≤ 1 y)* • Review at least 150 transthoracic echocardiograms with a qualified staff pediatric echocardiographer* • Participate in didactic conferences in which echocardiographic data are reviewed and their clinical applications are discussed • Reading of textbooks, review articles, and original research on pediatric echocardiography • Attendance at CME courses that are either dedicated to or include pediatric echocardiography
Advanced	In addition to the training methods described in the core level: • Perform at least 200 additional transthoracic echocardiograms (at least 50 in infants age ≤ 1 y) with subsequent review and critique of the examinations by the responsible staff pediatric echocardiographer* • Review at least 200 additional transthoracic echocardiograms with a qualified staff pediatric echocardiographer* • Trainees should gradually attain a high level of independence; the degree and rate at which independence is attained should be determined by the director of the laboratory • Prepare and present echocardiographic data at clinical and didactic conferences • Active participation in research that involves echocardiography of pediatric heart disease

CME, Continuing medical education.

*The recommended numbers of examinations outlined here represent minimal and not optimal requirements.

Formation

Targeted Neonatal Echocardiography in the Neonatal Intensive Care Unit: Practice Guidelines and Recommendations for Training

European Journal of Echocardiography (2011) **12**, 715–736

Table 3 Summary of training requirements

	Training level			
	Core/basic	Advanced	Expert	Accreditation
ACC/AHA/ASE pediatric echocardiography				
Number of studies	150 studies performed 150 studies reviewed	200 additional studies performed 200 additional reviewed	Not defined	None
Duration of training	4-6 mo	Additional 9-12 mo		
AEPC pediatric echocardiography				
Number of studies	250 studies performed	750 studies performed in total	2,000 studies performed in total	EAE congenital echocardiography exam
Duration of training	Not defined	1y	Not defined	
TNE guidelines				
Number of studies	150 studies reviewed 150 studies performed	150 additional studies reviewed 150 additional studies performed	Not defined	None
Duration of training	4-6 mo	Additional 4-6 mo	Not defined	None

Conclusions

- Echocardiographie: indispensable pour la chirurgie des CC

- **Echo pré-op:** diagnostic précis + stratégie per-op/post-op
- **Echo per-op:** valeur ajoutée +++, (quasiment) toujours faisable
- **Echo post-op:** guide la réanimation

- Nécessité d’un apprentissage rigoureux
- Collaboration multidisciplinaire