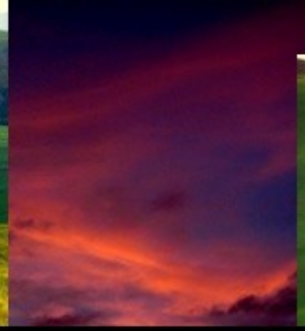




La Pulsossimetria puo' essere utilizzata per lo Screening delle Cardiopatie Congenite?



Claudio De Felice
U.O.C. Terapia Intensiva Neonatale
A.O.U.S., Siena

MALFORMAZIONI CARDIACHE CONGENITE

Freq. Cardiopatia Congenita "life-threatening" (Critical Congenital Heart Disease, CCHD):
1-2 /1000 n.v.

6-10% della mortalità infantile; 20-40% mortalità tot. da Malformazione Congenita

Esame clinico: diagnosi solo nel 46-62% dei neonati con CCHD=30%-40% dei neonati CCHD viene dimesso senza diagnosi (elevato rischio per: scompenso, mortalità a domicilio

Bonnet D, Coltri A, Butera G, Fermont L, Le Bidois J, Kachaner J, *et al.* Detection of transposition of the great arteries in fetuses reduces neonatal morbidity and mortality. Circulation 1999;99:916-8.

10-30% delle Critical Congenital Heart Disease (CCHD) viene identificata solo all'es. autoptico

5% dei neonati con CCHD muore senza diagnosi

CC e MORTALITA' INFANTILE (Bibliografia Essenziale)

Abu-Harb M, Hey E, Wren C. Death in infancy from unrecognised congenital heart disease. Arch Dis Child 1994;71:3-7.

Abu-Harb M, Wyllie J, Hey E, Richmond S, Wren C. Presentation of obstructive left heart malformations in infancy. Arch Dis Child Fetal Neonatal Ed 1994;71:F179-83.

Mellander M, Sunnegardh J. Failure to diagnose critical heart malformations in newborns before discharge—an increasing problem? Acta Paediatr 2006;95:407-13.

Wren C, Reinhardt Z, Khawaja K. Twenty-year trends in diagnosis of life-threatening neonatal cardiovascular malformations. Arch Dis Child Fetal Neonatal Ed 2008;93:F33-5

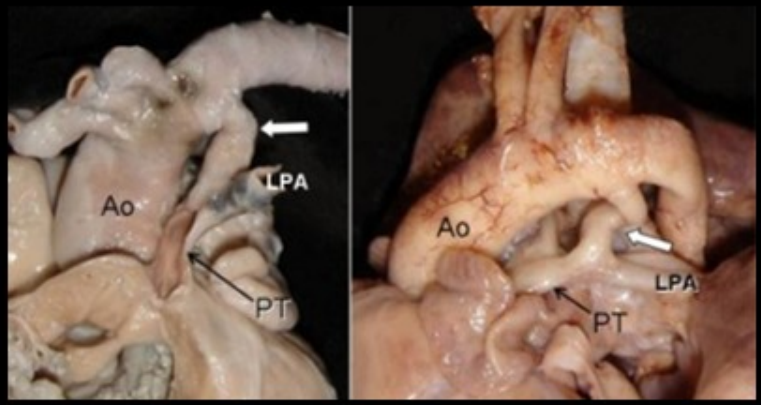
Bonnet D, Coltri A, Butera G, Fermont L, Le Bidois J, Kachaner J, *et al.* Detection of transposition of the great arteries in fetuses reduces neonatal morbidity and mortality. Circulation 1999;99:916-8.

Cardiopatie Congenite Dotto-Dipendenti
Duct-Dependent Heart Diseases (DDHD)

- Frequenza: 1-1.8/1000 n.v.
- Pervietà DA essenziale per la sopravvivenza
- Diagnosi Prenatale ≤ 20%
- All'esame clinico sono diagnosticabili solo 1/3 dei casi
- Se la diagnosi è effettuata PRIMA della dimissione, la mortalità è 16 volte inferiore (14.8% vs. 0.9%)
-N.B. Trend verso la anticipazione della dimissione dalla nursery

CCHD/DDHD

Trasposizione delle grandi arterie
Atresia polmonare
Stenosi aortica
Coartazione aortica
Sindrome del cuore sinistro ipoplasico
Interruzione dell'arco aortico
Difetto settale atrioventricolare



DIAGNOSI DDHD
(Bibliografia Essenziale)

Wren C, Reinhardt Z, Khawaja K. Twenty-year trends in diagnosis of life-threatening neonatal cardiovascular malformations. Arch Dis Child Fetal Neonatal Ed 2008;93:F33-5.

RosamondW, FlegalK, FridayG, FurieK, GoA, GreenlundK, *et al.* Heart disease and stroke statistics–2007 update: a report from the American Heart Association Statistics Committee and Stroke
Statistics Subcommittee. Circulation 2007;115:e69-171.

Richmond S, Reay G, AbuHarbM. Routine pulse oximetry in the asymptomatic newborn. Arch Dis Child Fetal Neonatal Ed 2002;87:F83-8.

Koppel RI, Druschel CM, Carter T, Goldberg BE, Mehta PN, Talwar R, *et al.* Effectiveness of pulse oximetry screening for congenital heart disease in asymptomatic newborns. Pediatrics 2003;111:451-5.

La Pulsossimetria (*) può essere utilizzata per lo screening precoce delle CCHD (ed in particolare delle DDHD)?

(*) Aoyagi T, Miyasaka K (2002) Pulse oximetry: its invention, contribution to medicine, and future tasks. Anesth Analg 94[Suppl 1]: S1–S3

PULSOSSIMETRIA NEONATALE: TEST POSITIVO

SpO2 pre- e post-duttale <95% o in caso di differenza > 3% fra le 2 misure (PRE-DUTTALE: palmo mano destra *vs.* POST-DUTTALE: piede) entro le prime 24 h di vita.

Screening sistematico delle CCHD/DDHD mediante differenza pulsossimetrica pre- post-duttale della saturazione dell'ossiemoglobina (SpO2):

STUDI PUBBLICATI

Richmond S, Reay G, AbuHarbM. Routine pulse oximetry in the asymptomatic newborn. Arch Dis Child Petal Neonatal Ed 2002;87:P83-8.

Koppel RI, Druschel CM, Carter T, Goldberg BE, Mehta PN, Talwar R, *et al.* Effectiveness of pulse oximetry screening for congenital heart disease in asymptomatic newborns. Pediatrics 2003;111:451-5.

Kuehl KS, Loffredo CA, Ferencz C. Failure to diagnose congenital heart disease in infancy. Pediatrics 1999;103:743-7.

Hoke TR,Donohue PK,BawaPK, MitchellRD, PathakA, Rowe PC, *et al.* Oxygen saturation as a screening test for critical congenital heart disease: a preliminary study. Pediatr Cardiol 2002;23:403-9.

ReichJD,MillerS,Broglon B, Casatelli J,Gompf TC,Huhta JC, *et al.* The use of pulse oximetry to detect congenital heart disease. J Pediatr 2003;142:268-72.

Bakr AF, Habib HS. Combining pulse oximetry and clinical examination inscreening for congenitalheart disease. PediatrCardiol 2005;26:832-5.

Rosati E, Chitano G, Dipaola L, De Felice C, Latini G. Indications and limitations for a neonatal pulse oximetry screening of critical congenital heart disease. J PerinatMed 2005;33:455-7.

De-Wahl Granelli A,MellanderM, Sunnegardh J, Sandberg K,Östman -Smith I. Screening for duct-dependent congenital heart disease with pulse oximetry: a critical evaluation of strategies to maximize sensitivity. Acta Paediatr 2005;94:1590-6.

Arlettaz R, Bauschatz AS, Monkhoff M, Essers B, Bauersfeld U. The contribution of pulse oximetry to the early detection of congenital heart disease in newborns. Eur J Pediatr 2006;165:94-8.

Screening sistematico delle CCHD/DDHD mediante differenza pulsossimetrica pre- post-duttale della saturazione dell'ossiemoglobina (SpO_2):

LIMITI

Ridotte dimensioni del campione (*n* range: 2114-11281)

Mancata considerazione casi di morte nella comunità da CCHD non diagnosticata (ca. 5% , v. Wren et al., 2008)

Differenze nei protocolli di screening e nelle strategie di follow - up

Screening sistematico delle CCHD/DDHD mediante differenza pulsossimetrica pre- post-duttale della saturazione dell'ossiemoglobina (SpO_2):

STUDIO BMJ - Online, Jan 2009- METODOLOGIA

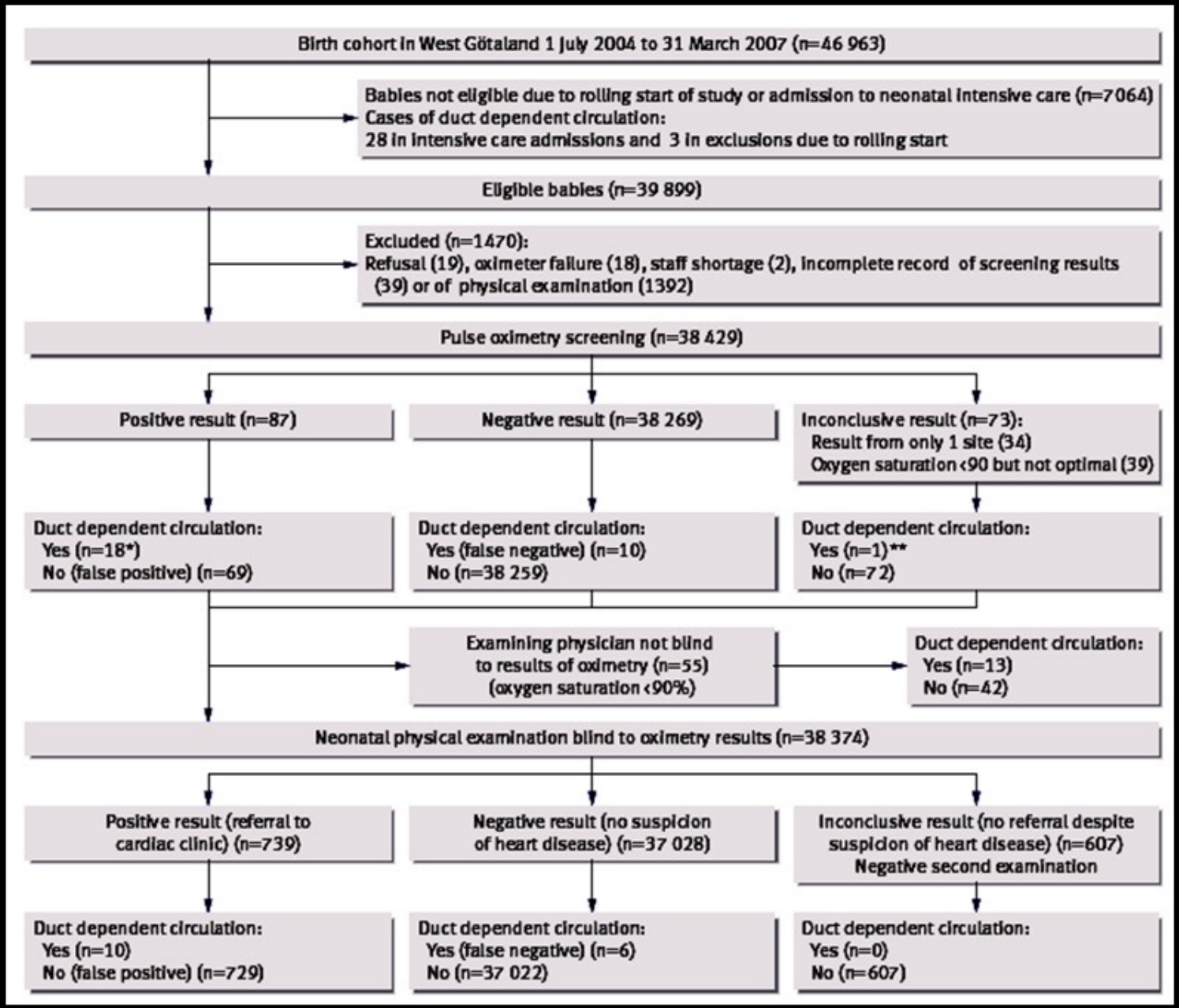
Tipo di Studio: **Prospettico**
Neonati NICU: **-**
Neonati screenati: **n=38429 (nursery)**
Sede: **Svezia (W. Gotaland)**
Periodo esaminato: **2004-2007**
Centri nascita coinvolti: **5**
Follow – Up in comunità: **+**

de-Wahl Granelli A, Wennergren M, Sandberg K, Mellander M, Bejlum C, Inganäs L, Eriksson M, Segerdahl N, Agren A, Ekman-Joelsson BM, Sunnegårdh J, Verdicchio M, Ostman-Smith I. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Screening sistematico delle CCHD/DDHD mediante differenza pulsossimetrica pre- post-duttale della saturazione dell'ossiemoglobina (SpO2):

STUDIO BMJ, 2009- DATI IN DETTAGLIO

de-Wahl Granelli A, Wennergren M, Sandberg K, Mellander M, Bejlum C, Inganäs L, Eriksson M, Segerdahl N, Agren A, Ekman-Joelsson BM, Sunnegårdh J, Verdicchio M, Ostman-Smith I. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.



18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Final diagnosis	Pulse oximetry screening		Physical examination		
	Preductal/postductal oxygen saturation (%)	Test result	Murmur present (day of life)	Femoral pulses	Referral for echocardiography
Referred for urgent echocardiography according to protocol*					
TGA	47/22	+ve	No	Normal	N/A
TGA	59/59	+ve	No	Normal	N/A
TGA, PA, DILV	65/72	+ve	Yes	Normal	N/A
PA, VSD	75/84	+ve	Yes	Normal	N/A
PA, VSD	78/83	+ve	Yes	Normal	N/A
Critical AS, CoA	86/46	+ve	Yes	Very weak	N/A
TGA, DILV	85/89	+ve	Yes	Normal	N/A
Critical AS	93/80	+ve	Yes	Weak	N/A
CoA, VSD	99/86	+ve	No	Weak	N/A
TGA, CoA, VSD	87/93	+ve	Faint	Normal	N/A
Critical PS	70/60	+ve	Faint	Weak	N/A
HLHS	90/91	+ve	Yes	Weak	N/A
TGA, DILV, CoA	91/93; 94/91	+ve	Faint	Very weak	N/A

18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Final diagnosis	Pulse oximetry screening		Physical examination		
	Preductal/postductal oxygen saturation (%)	Test result	Murmur present (day of life)	Femoral pulses	Referral for echocardiography
Blind neonatal examination					
Critical SAS	98/89; 98/94	+ve	Yes (day 2)	Normal	Yes
HLHS	90/93; 92/92; 91/94	+ve	Faint (day 2)	Normal	Yes
CoA	97/postductal value (foot) unrecordable	Pathological result	No (day 1)	Weak	Yes, arrhythmia
IAA, TGA, DILV	97/92; 97/93; 95/90	+ve	Yes (day 4)	Weak	Yes
HLHS	96/82; 95/81	+ve	Yes (day 2)	Difficult (crying)	Yes
IAA, TA	95/96	−ve	Yes (day 1)	Increased	Yes
Aortic atresia, AVSD, CoA	96/96; 90/92	−ve	No (day 1)	Normal	No
			Yes (day 2)		Yes (no urine)
CoA, ASD	100/99; 99/100	−ve	Yes (day 1)	Impalpable	No
			Yes (day 2)	Impalpable	Yes
CoA	98/99	−ve	Yes (days 1-4)	Normal	Yes
			Faint (day 5)	Impalpable	
CoA	99/100	−ve	Yes (day 3)	Palpable	Yes
			No (day 4)	Impalpable	

18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Final diagnosis	Pulse oximetry screening		Physical examination		
	Preductal/postductal oxygen saturation (%)	Test result	Murmur present (day of life)	Femoral pulses	Referral for echocardiography
Discharged home without diagnosis and echocardiography					
IAA, AP window	98/92; 99/95	+ve	No (day 1)	Normal	No (protocol violation)
			Circulatory collapse day 8		—
CoA	99/93; 95/95	−ve	No (day 2)	Normal	No
			Circulatory collapse day 7		—
CoA, VSD	98/100	−ve	No (day 2)	Normal	No
			Circulatory collapse day 4		—
IAA, ASD	97/99	−ve	No (day 1)	Normal	No
			Circulatory collapse day 4		—
CoA	99/97	−ve	No (day 1)	Normal	No
			Circulatory collapse day 4		—

18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Performance	Physical examination alone (n=38374)	Pulse oximetry (n=38429)	Physical examination plus pulse oximetry (n=38429)
Sensitivity (95% CI) (%)	62.50 (35.43 to 84.80)*	62.07 (42.3 to 79.31)	82.76 (64.23 to 94.15)
Specificity (95% CI) (%)	98.07 (97.93 to 98.21)	99.82 (99.77 to 99.86)	97.88 (97.73 to 98.03)
Positive predictive value (95% CI) (%)	1.35 (0.65 to 2.47)	20.69 (12.75 to 30.71)	2.92 (1.88 to 4.31)
Negative predictive value (95% CI) (%)	99.98 (99.96 to 99.99)	99.97 (99.95 to 99.99)	99.99 (99.97 to 100.00)
Likelihood ratio	32.37	344.8	39.08
False-positive rate (%)	1.90	0.17†	2.09
No of true positives	10*	18‡	24‡
No of false negatives	6*	11§	5§
No of false positives	729	69	798
No of true negatives	37 022	38 259	36881
Relative risk (95% CI) (%)	83.6 (30.5 to 229.5)	719.8 (350.3 to 1479)	215.4 (82.4 to 563.0)

18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Pathology found	No (%) of babies	Subsequent management			
		Stay in neonatal intensive care			
		≥5 days after screening	<5 after screening	Follow-up only	Surgery
Other critical congenital heart disease*	4 (6)	4/4	0/4	0/4	4/4
Other milder congenital heart disease	10 (14)	4/10	1/10	5/10	4/10
Persistent pulmonary hypertension	6 (9)	3/6	0/6	3/6	N/A
Transitional circulation†	8 (12)	0/8	3/8	2/8	N/A
Infections	10 (14)	6/10	4/10	N/A	N/A
Pulmonary pathology	7 (10)	5/7	1/7	1/7	N/A
Normal (verified from hospital charts)	24 (35)	N/A	N/A	N/A	N/A

18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Type of duct dependent circulation	West Götaland	Other referring regions	Comparison
Systemic circulation	5/30 (17)	16/48 (33)	P=0.12
Lung and mixing circulation	0/30 (0)	12/52 (23)	P=0.0030
Total	5/60 (8)	28/100 (28)	P=0.0025; relative risk 3.36 (95% CI 1.37 to 8.24)

18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Diagnoses	Sequelae: Severe acidosis	Sequelae: Death within 30 days
Pulmonary and mixing duct dependent circulation		
TGA	No	No
TGA	No	No
TGA	Yes	No
TGA	Yes (+ preoperative seizures)	No
TGA	Yes (ECMO, preoperative cerebral haemorrhage)	No
TGA, VSD	No	No
TGA, VSD	No	No
Complex TGA	N/A	Yes, undiagnosed
Pulmonary flow duct dependent circulation		
TGA, PA, VSD	No	No
TGA, PA	No	No
PA	N/A	Yes, undiagnosed
Systemic and mixing duct dependent circulation		
TGA, CoA, VSD	Yes, brain infarction, cerebral haemorrhage, preoperative seizures	No

Diagnoses	Sequelae: Severe acidosis	Sequelae: Death within 30 days
Systemic flow duct dependent circulation		
HLHS	N/A	Yes, undiagnosed
Critical AS	No	No
IAA, truncus arteriosus	Yes (pH 6.80)	No
IAA, VSD	No	No
CoA, VSD	Yes (pH 6.90)	No
CoA, VSD	N/A	Yes, undiagnosed
CoA, VSD	No	No
CoA, VSD	N/A	Yes, undiagnosed
CoA, AVSD	No	No
CoA	Yes	No
CoA	Yes	No
CoA	Yes	No
CoA	No	No
CoA	No	No
CoA	Yes (pH 7.14)	No
CoA	No	No

ECMO=extracorporeal membrane oxygenation, N/A=information not available as infant died at home (severe acidosis would have preceded death), TGA=transposition of the great arteries, PA=pulmonary atresia, VSD=ventricular septal defect, AS=aortic stenosis, CoA=coarctation of the aorta, HLHS=hypoplastic left heart syndrome, IAA=interrupted aortic arch, AVSD=atrioventricular septal defect.

18 de-Wahl Granelli A. et al. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

Screening sistematico delle CCHD/DDHD mediante differenza pulsossimetrica pre- post-duttale della saturazione dell'ossiemoglobina (SpO2):

STUDIO BMJ, 2009 – SINTESI (1)

Neonati CCHD diagnosticati : 92% (vs. 72% in area Svezia "no screening", *P*=0,0025)
Mortalità neonatale per CCHD: n= 0 (vs. n= 5 nello stesso periodo in area della Svezia "no screening")
Falsi positivi: n=69 (0,17%) ma 31/69 FP (44,9%) con patologia signif. non-diagnosticata (cardiaca, polmonare, sepsi).
Costo stimato screening: 3430 £/diagnosi precoce
Costo stimato screening mancato: 3453 £/ neonato CCHD mancato (*)
Costo stimato diagnosi CCHD senza screening: 7700 £/diagnosi (ecocardiografia sulla base reperti es. clinico)
Costo stimato diagnosi CCHD senza screening: 2526 £/diagnosi (ecocardiografia sulla base di desaturazione≤90%)

(*) Griebsch I, Knowles RL, Brown J, Bull C, Wren C, Dezateux CA. Comparing the clinical and economic effects of clinical examination,
pulse oximetry, and echocardiography in newborn screening for congenita lheart defects:aprobabilistic <cost-effectivenessmodeland
value of information analysis. Int J Technol Assess Health Care 2007;23:192-204.

WHAT THIS STUDY ADDS

As inpatient maternity stays have reduced, an increasing proportion of babies with duct dependent pulmonary circulation leave hospital undetected

Pulse oximetry screening performed both preductally and postductally detects 100% of infants with pulmonary duct dependent circulation and, when combined with routine clinical examination, detects 92% of all infants with duct dependent circulation before hospital discharge, and has a higher detection rate than physical examination alone

Introduction of pulse oximetry screening is cost neutral in the immediate perspective, as each additional case that receives a timely diagnosis costs the same as the treatment of a child that is readmitted in circulatory collapse, but there are probably additional long term cost benefits from reduced neurological morbidity

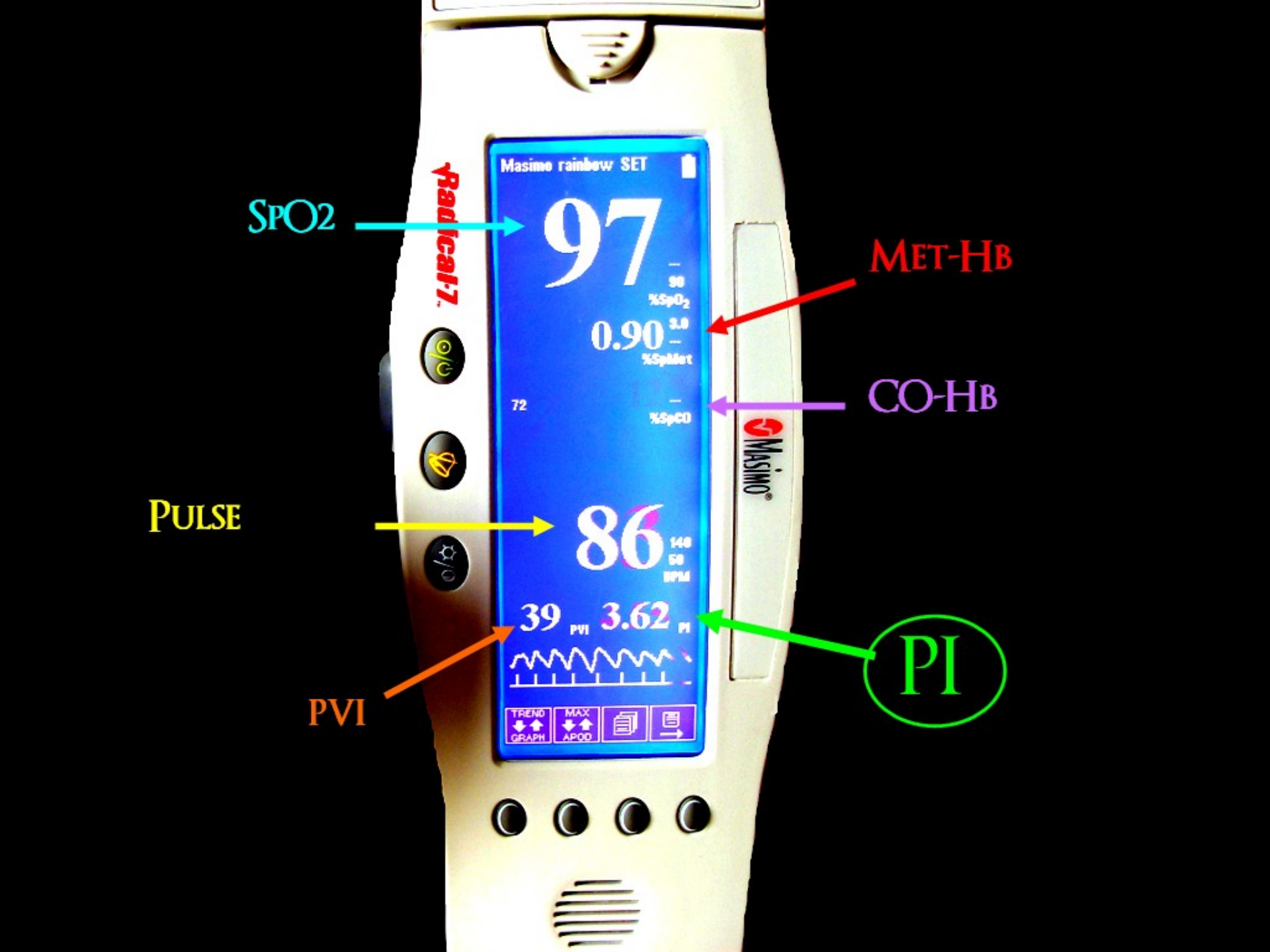
de-Wahl Granelli A, Wennergren M, Sandberg K, Mellander M, Bejlum C, Inganäs L, Eriksson M, Segerdahl N, Agren A, Ekman-Joelsson BM, Sunnegårdh J, Verdicchio M, Ostman-Smith I. Impact of pulse oximetry screening on the detection of duct dependent congenital heart disease: a Swedish prospective screening study in 39,821 newborns. BMJ. 2009 Jan 8;338:a3037. doi: 10.1136/bmj.a3037.

INDICE DI PERFUSIONE (P.I.) e SCREENING CCHD: PROSPETTIVE

Una promettente area di ricerca riguarda l'utilizzazione dell'indice di perfusione (Perfusion Index, P.I.), individuato da De Felice *et al*, che presenta grandi potenzialità nella diagnosi precoce delle DDHD

De Felice C, Latini G, Vacca P, Kopotic RJ. The pulse oximeter perfusion index as a predictor for high illness severity in neonates. Eur J Pediatr. 2002 Oct;161(10):561-2. **20** De Felice C, Del Vecchio A, Criscuolo M, Lozupone A, Parrini S, Latini G. Early postnatal changes in the perfusion index in term newborns with subclinical chorioamnionitis. Arch Dis Child Fetal Neonatal Ed. 2005 Sep;90(5):F411-4.

De-Wahl Granelli A, Östman-Smith I. Noninvasive peripheral perfusion index as a possible tool for screening for critical left heart obstruction. Acta Paediatr 2007;96:1455-9.

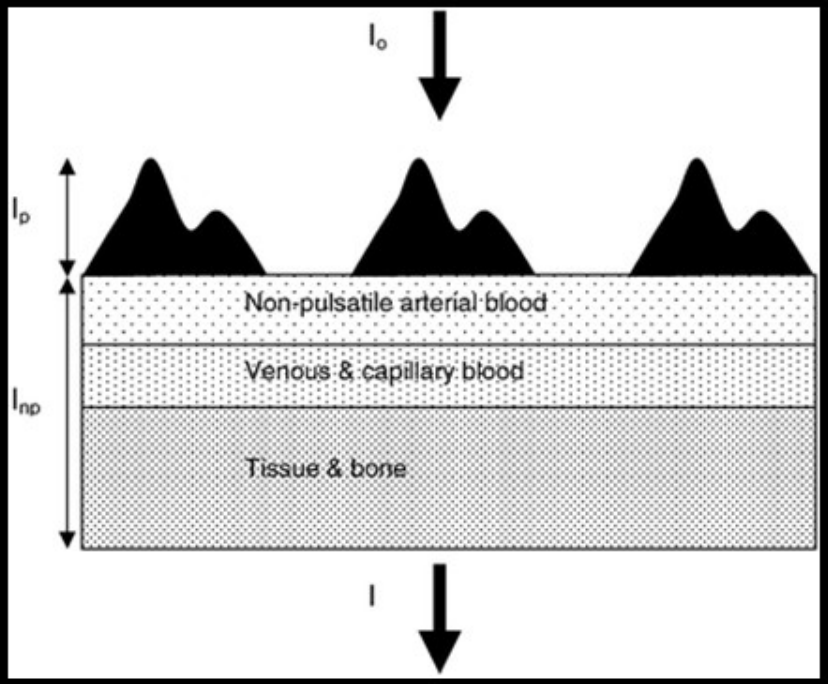

SpO2
Met-Hb
CO-Hb
Pulse
PVI
PI
Masimo rainbow SET
97
%SpO2
0.90
%SpMet
72
%SpCO
86
BPM
39
PVI
3.62
PI
TREND GRAPH
MAX APOD
Radical-7
Masimo

Measuring peripheral perfusion in medicine: an overview

METHOD	VARIABLE	ADVANTAGE	LIMITATIONS
Pulse oximetry	PFI	Easily obtainable; reflect real time changes in peripheral blood flow	Not accurate during patient motion
NIRS	Hb, HbO_2, and HbT variations	Assessment of oxygenation in all vascular compartments; can be applied to measure regional blood flow and oxygen consumption	Requires specific software to display the variables
	StO_2		
	$Cytaa_3$		
OPS	FCD	Direct visualization of the microcirculation	Observer-related bias; semiquantitative measure of perfusion
LDF	Microvascular blood flow	Useful method to evaluate endothelium-dependent vascular responses	Small sampling volume for cutaneous blood flow measurement; does not reflect heterogeneity of blood flow
Transcut. oximetry	$PtcO_2/PtcCO_2$	Direct measurement of $PtcO_2/PtcCO_2$; early detection of peripheral hypoperfusion	Necessity to frequently change the sensor position; requires blood gas analysis
	Tc-index		
Sublingual capnometry	$PslCO_2$	Direct measurement of tissue PCO_2 noninvasively	Requires blood gas analysis to obtain $PaCO_2$; normal and pathological values not yet defined
	Psl-aCO_2		

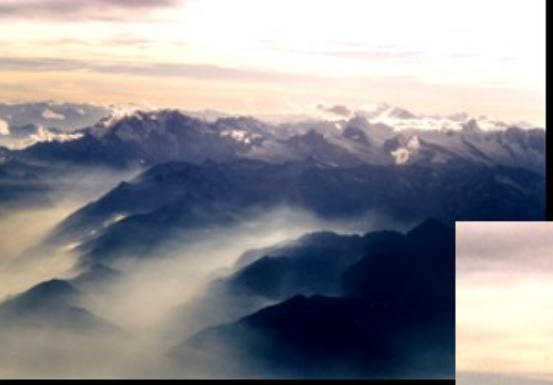
Lima A, Bakker J: Noninvasive monitoring of peripheral perfusion. Intensive Care Med 2005; 31:1316-1326

Noninvasive monitoring of peripheral perfusion

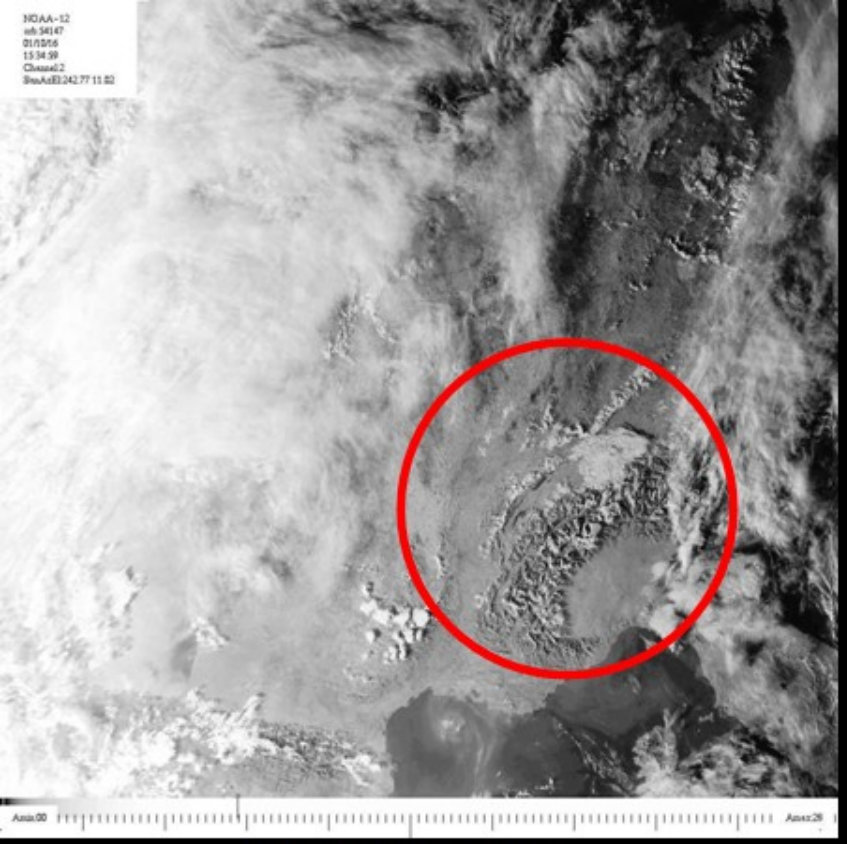


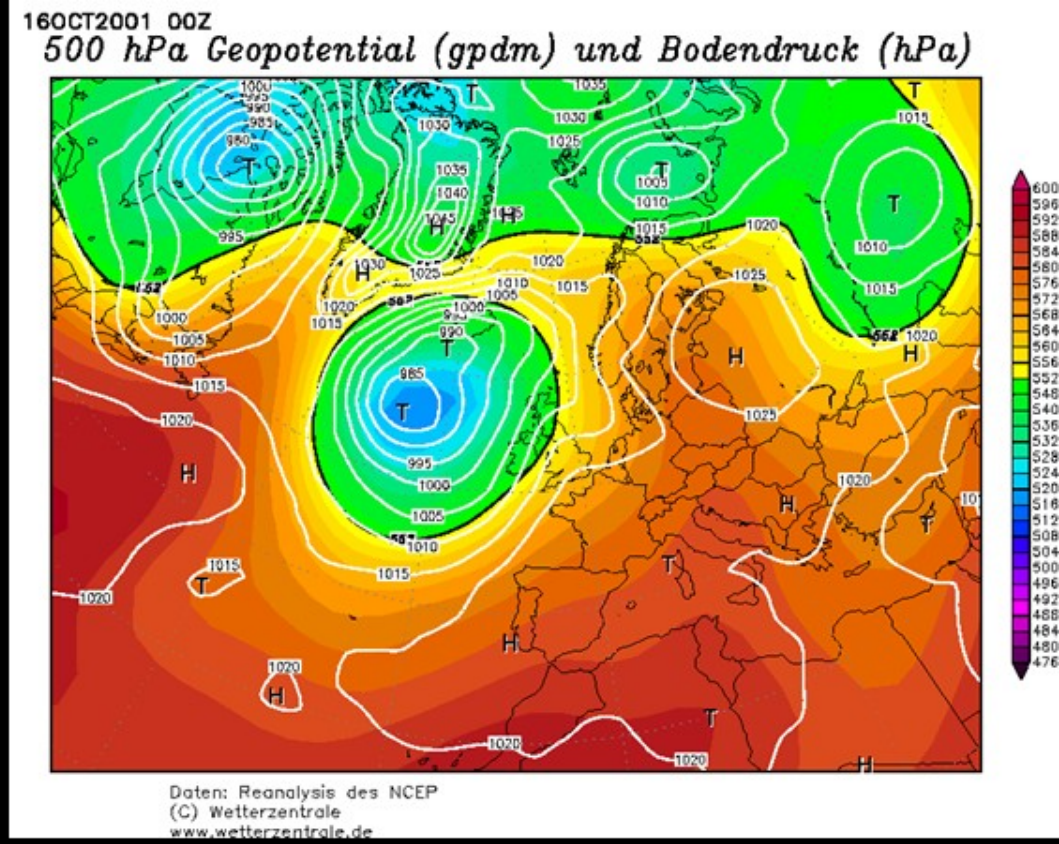
$$PI = (V_{max} - V_{min}) / V_{max\ mean}$$

PI SERENDIPITOUS DISCOVERY



Aoyagi T, Miyasaka K (2002) Pulse oximetry: its invention, contribution to medicine, and future tasks. Anesth Analg 94[Suppl 1]: S1–S3
De Felice C, et al. The pulse oximeter perfusion index as a predictor for high illness severity in neonates. Eur J Pediatr. 2002 Oct;161(10):561-2.
Granelli AW, et al. Noninvasive peripheral perfusion index as a possible tool for screening for critical left heart obstruction. Acta Paediatr. 2007 Oct;96(10):1455-9.
Cannesson M, et al. Pleth variability index to monitor the respiratory variations in the pulse oximeter plethysmographic waveform amplitude and predict fluid responsiveness in the operating theatre. Br J Anaesth. 2008 Aug;101(2):200-6.





October 16, 2001
Pisa – London, 9 AM

Severe air turbulence (CAT)
over the Alps

Male premature infant

Drop in PI (< 0.5)

↓

Tachycardia (PR > 180 bpm)

↓

Hypoxia (SpO2 < 50 %)

Perfusion Index Timeline

2001

Rediscovering PI (De Felice C)

2002

PI and Neonatal illness severity (De Felice C et al.)

PI and perfusion assessment in adult ICU patients (Lima AP et al.)

2005

PI and early diagnosis of HCA (De Felice C et al.)

PI validation as a real "perfusion index" (Zaramella P et al.)

PI and thoracic sympathectomy (Klodell CT et al.)

PI and epidural onset assessment in obstetric anesthesia (Kakazu CZ et al.)

2006

PI, pulse oximeters and hypothermia (Nishiyama T)

PI and dinamic changes in HCA neonates (De Felice C et al.)

No PI changes in rabbit experimental sepsis (Hummler HD et al.)

PI and gastroschisis silo oxygenation monitoring (Kim S et al.)

2007

PI and early neonatal detection of DDHD (Granelli AW & Ostman-Smith I)

2008

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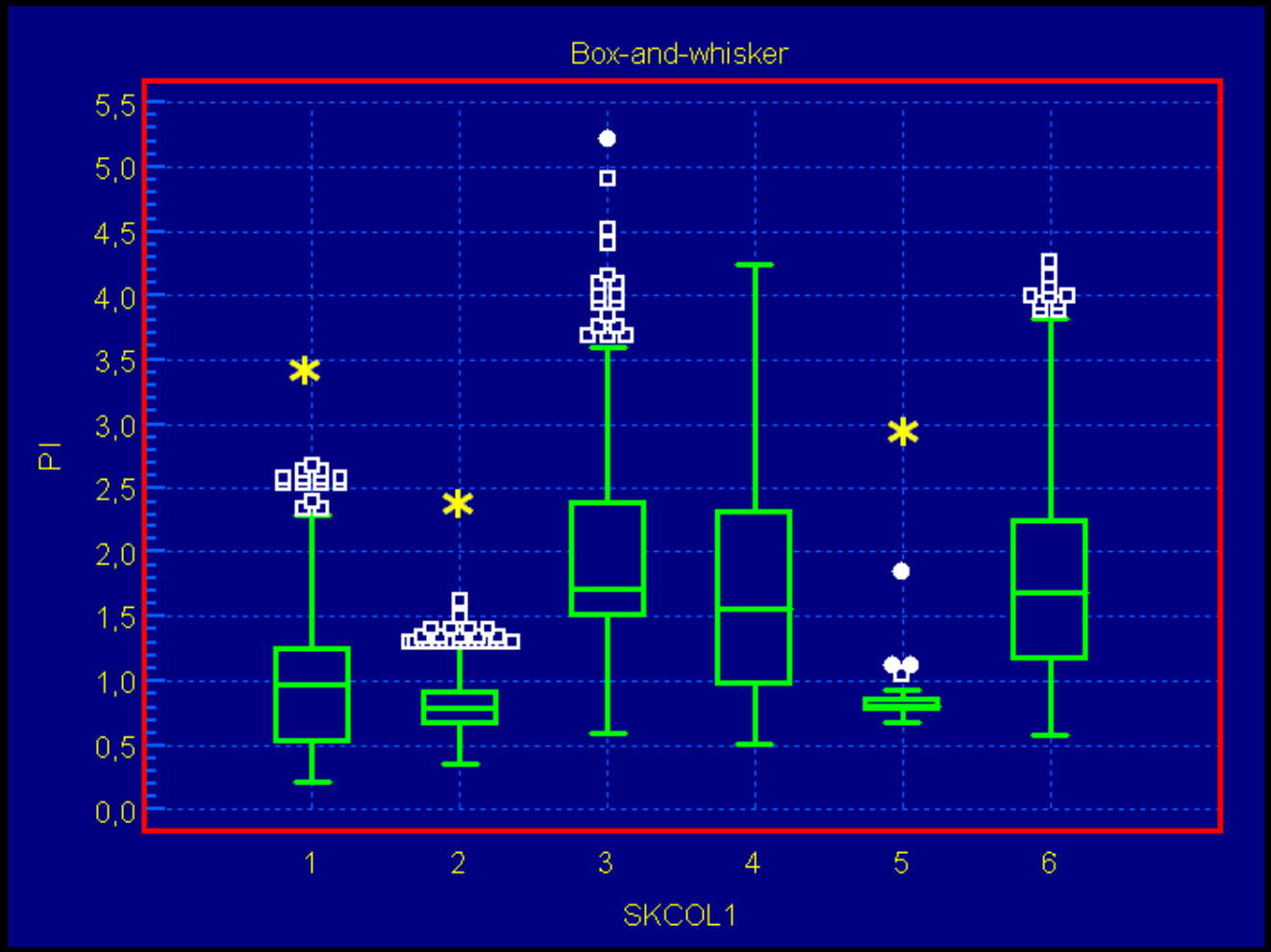
Pulse-Oximetry & Skin Color

Reflected light carries information on the physico-chemical properties of the interacting objects

P.I. & Subjective Skin Color Estimate



1=Pale 2=Gray 3=Yellow 4=Red 5=Blue 6=Pink

* 1-way ANOVA, *F*-ratio=208.58, *P*<0.0001

Perfusion Index Timeline

2001 Rediscovering PI (De Felice C)

2002 **PI and Neonatal severity (De Felice C et al.)**

PI and perfusion assessment in adult ICU patients (Lima AP et al.)

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Key characteristics for the "ideal" clinical marker of neonatal illness severity

- **Accurate/reproducible**
- **Non-invasive**
- **Provides Real-Time information**

Why do neonatal illness severity matter?

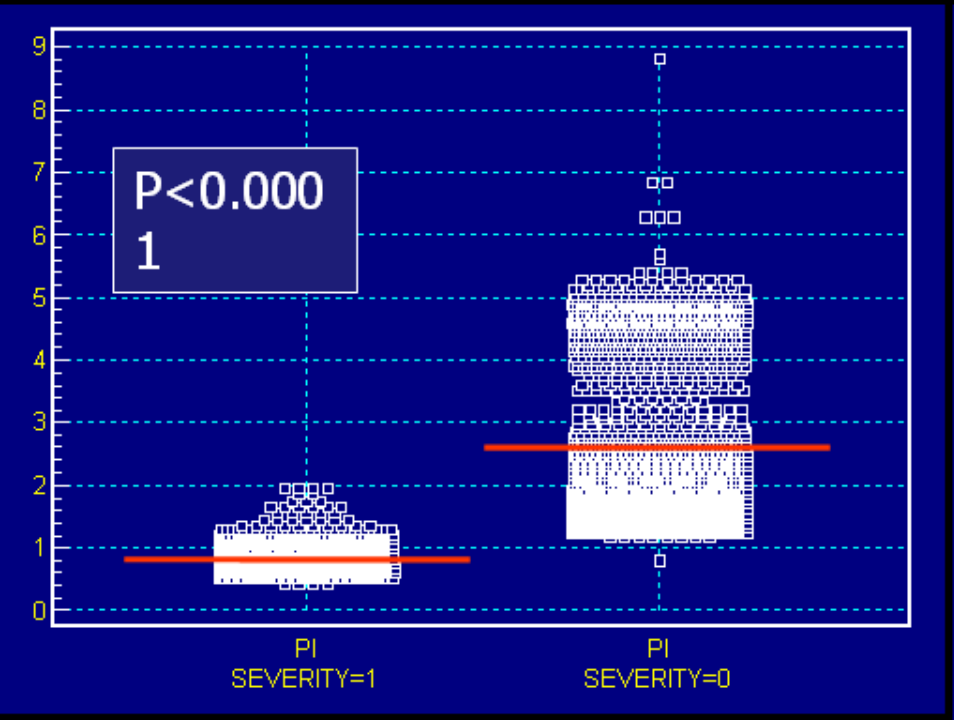
- Quality of care control
- (Unbiased) intra- and inter-NICU comparisons (clinical studies)
- Management studies
- Rational use of resources

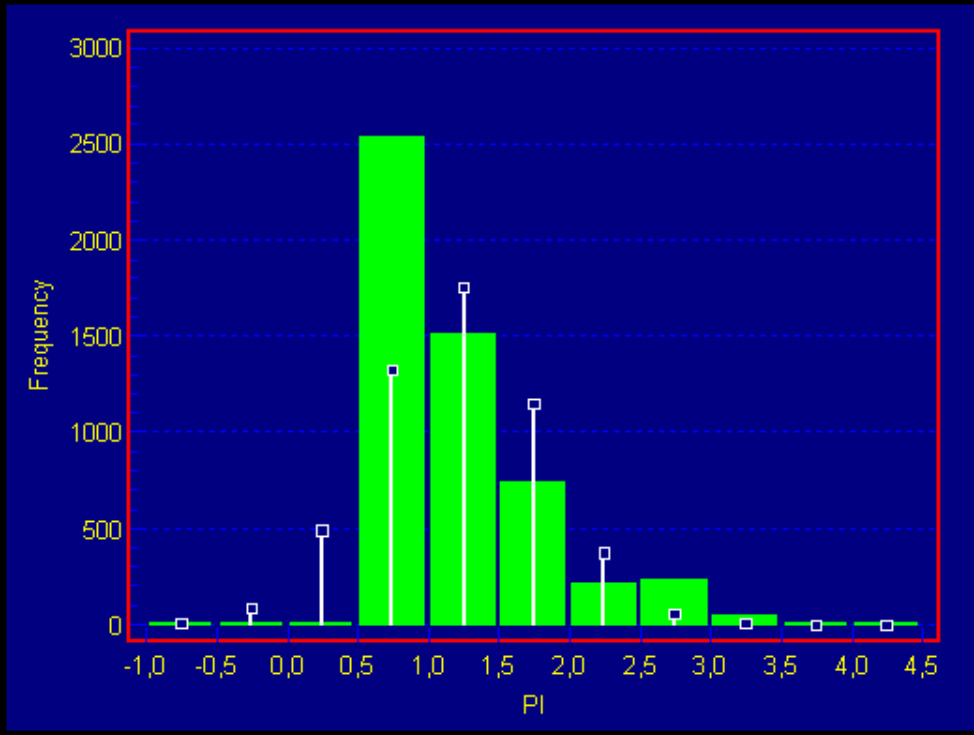
Neonatal Illness Severity Scoring Systems Variables / Items

- Gender
- Gestational age
- Birth weight
- Body temperature
- Base excess
- Congenital malformations
- Minimum appropriate FiO_2
- Maximum appropriate FiO_2
- PO_2/FiO_2 ratio
- Blood pressure
- Serum pH
- Multiple seizures
- Urine output
- Apgar score
- Small for date

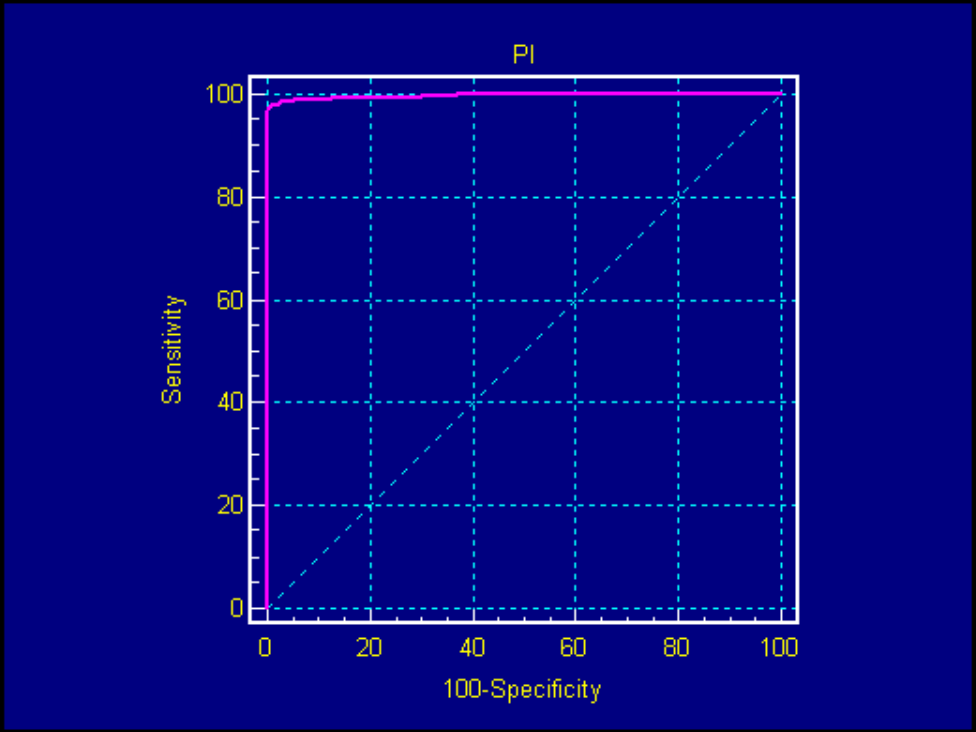
Low PI values in high severity newborns at NICU admission

De Felice C, Latini G, Vacca P, Kopotic RJ. The pulse oximeter perfusion index as a predictor for high illness severity in neonates. Eur J Pediatr. 2002 Oct;161(10):561-2.





PI & ILLNESS SEVERITY: ROC CURVE ANALYSIS



AUC= 0.997 (95% CI:0.995-0.998)
CUTOFF<=1.24
SENS: 97.6 (97.0-98.1) %
SPEC: 99.7 (99.5-99.9) %
+PV: 99.7%
-PV: 98.1%

Low PI: Mechanisms?

- Early peripheral microcirculatory changes
- Local skin vasoconstriction

Poschl JM, Weiss T, Fallahi F, Linderkamp O. Reactive hyperemia of skin microcirculation in septic neonates. *Acta Paediatr* 1994;83:808-11.

Eur J Pediatr (2002) 161: 561–562
DOI 10.1007/s00431-002-1042-5

RESEARCH LETTER

Claudio De Felice · Giuseppe Latini · Paola Vacca
Robert J. Kopotic

The pulse oximeter perfusion index as a predictor for high illness severity in neonates

Received: 23 April 2002 / Accepted: 9 July 2002 / Published online: 3 September 2002

Pubblicazioni PI

1: De Felice C, Mazzieri S, Pellegrino M, Del Pasqua A, Toti P, Bagnoli F, RosatiE, Latini G.
Skin reflectance changes in preterm infants with patent ductusarteriosus. Early Hum Dev. 2004 Jun;78(1):45-51..

2: De Felice C, Del Vecchio A, Criscuolo M, Lozupone A, Parrini S, Latini G.
Early postnatal changes in the perfusion index in term newborns with subclinical chorioamnionitis.
Arch Dis Child Fetal Neonatal Ed. 2005
Sep;90(5):F411-4. Epub2005 Apr 29. PubMed PMID: 15863488;

3: De Felice C, Goldstein MR, Parrini S, Verrotti A, Criscuolo M, Latini G. Earlydynamic changes in pulse oximetry signals in preterm newborns with histologic chorioamnionitis. Pediatr Crit Care Med. 2006 Mar;7(2):138-42.

4: De Felice C, Latini G, Vacca P, Kopotic RJ. The pulse oximeter perfusion indexas a predictor
for high illness severity in neonates. Eur J Pediatr. 2002Oct;161(10):561-2. Epub 2002 Sep 3.

5: De Felice C, Leoni L, Tommasini E, Tonni G, Toti P, Del Vecchio A, Ladisa G,Latini G.
Maternal pulse oximetry perfusion index as a predictor of early adverserespiratory neonatal
outcome after elective cesarean delivery. Pediatr Crit Care Med. 2008 Mar;9(2):203-8.

6: De Felice C, Ciccoli L, Leoncini S, Signorini C, Rossi M, Vannuccini L, GuazziG, Latini G,
Comporti M, Valacchi G, Hayek J.
Systemic oxidative stress in classic Rett syndrome. Free Radic Biol Med. 2009 May 20. [Epub ahead of print]

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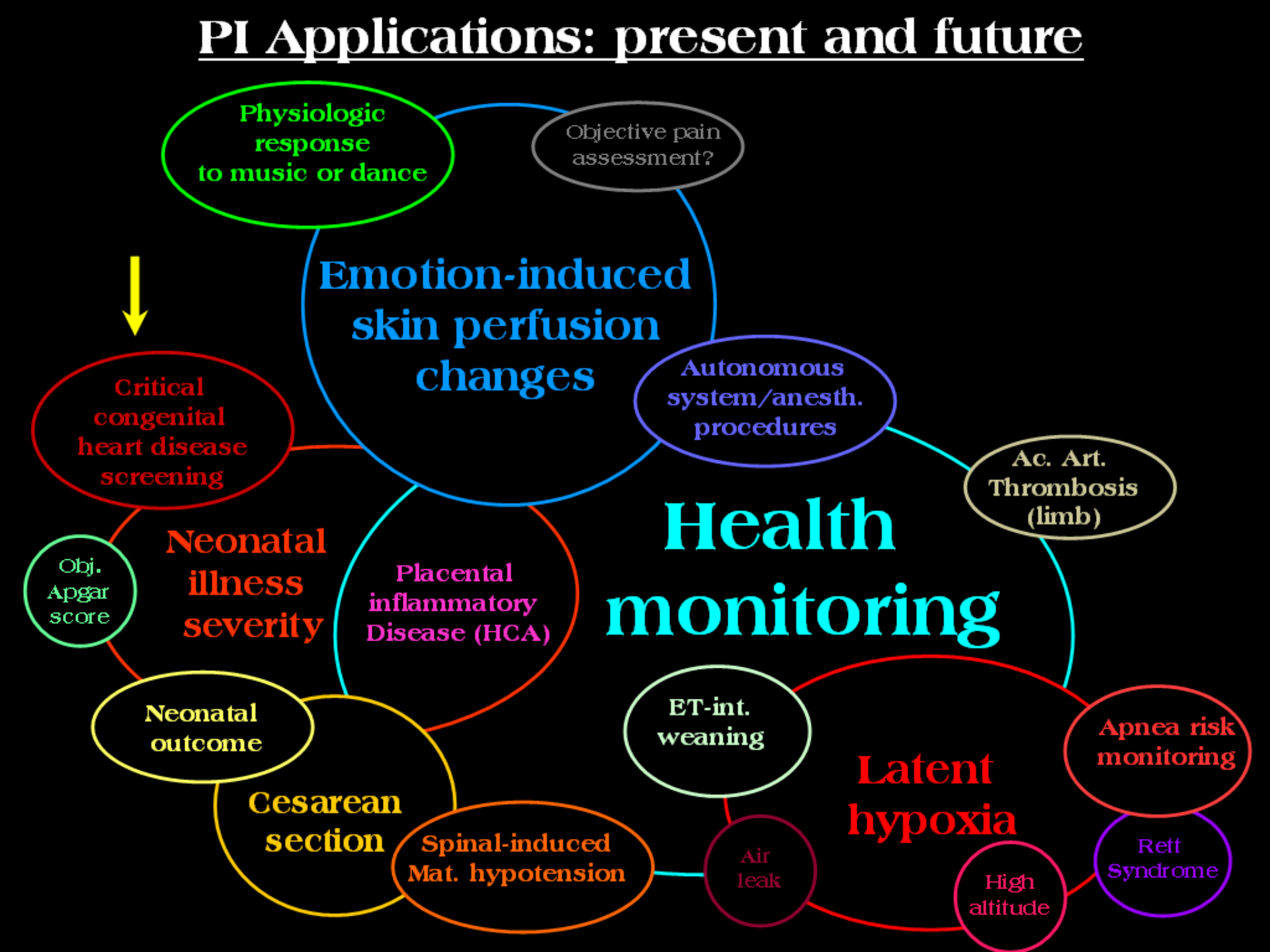
PI & CCHD:
ancora una volta c'entra la "*serendipity*"...

positive, 0 (0%) false negative, and 297 (90.27%) true negative results. The accuracy of the 1-min and 5-min PI screenings showed 100% sensitivity (95% CI: 88.3-100%), 99.4% specificity (95% CI: 97.8-99.9), 93.7% positive predictive, and 100% negative predictive value in identifying a HCA. The two infants showing false positive results were subsequently diagnosed of having a congenital heart defect [Ebstein anomaly (median PI value in the first 5 minutes: 0.68; interquartile range: 0.53-0.83) and non-ductal-dependent aortic coarctation (median PI value in the first 5 minutes: 0.75, interquartile range: 0.54-0.96)]. No specific differences between the PI evaluations at 1 and 5 minutes were observed. The application of the PI screening to the study phase 2

2: De Felice C, Del Vecchio A, Criscuolo M, Lozupone A, Parrini S, Latini G.
Early postnatal changes in the perfusion index in term newborns with subclinical chorioamnionitis.
Arch Dis Child Fetal Neonatal Ed. 2005
Sep;90(5):F411-4. Epub2005 Apr 29. PubMed PMID: 15863488;

PI Applications: present and future



PI e LOHD (left heart obstructive disease)

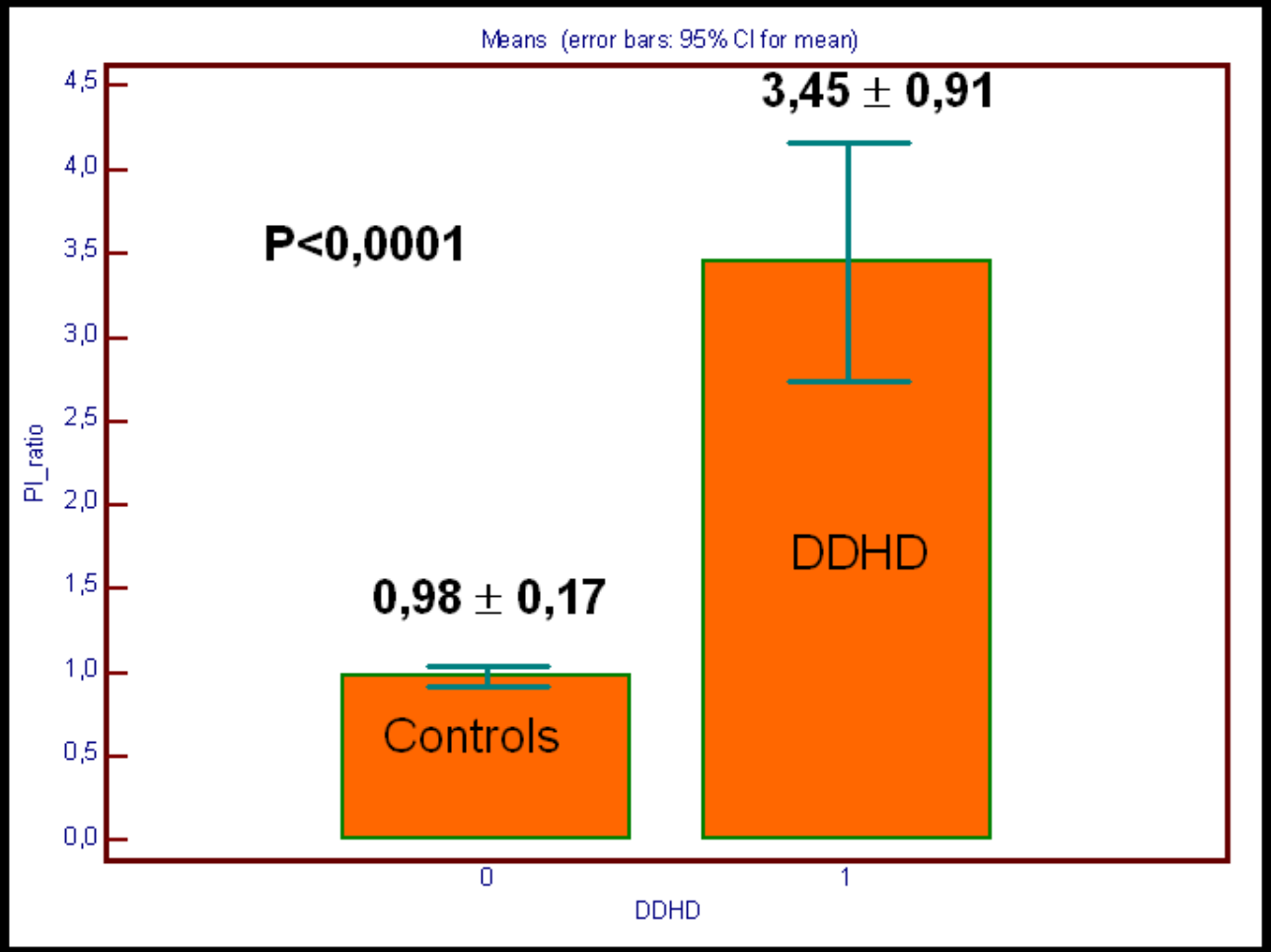
PI<0.70 è indicativo di LOHD

PI 5° pct = 0.70, IQR: 1,18-2,50; 95° pct=4,50

N=10 000 neonati screenati
Neonati con LOHD = 9 (0,9/1000 n.v.)
LOHD con PI<5° pct= 5/9=56%
Odds ratio per LHOD = 23.75 (95% CI 6.36-88.74)

De-Wahl Granelli A, Östman-Smith I. Noninvasive peripheral perfusion index as a possible tool for screening for critical left heart obstruction. Acta Paediatr 2007;96:1455-9.

RAPPORTO P.I. PRE / POST-DUTTALE NELLE PRIME 24 H DI VITA



(PRE-DUTTALE: palmo mano destra *vs.* POST-DUTTALE: piede)

De Felice C, 2009

CONCLUSIONI

-Importanza epidemiologica CCHD (1-2/1000 n.v.)

- Fattibilità / importanza e costo/beneficio dello screening neonatale precoce delle CCHD mediante pulsossimetria convenzionale nelle prime 24-48 hh di vita da parte del personale infermieristico della nursery

-Rapporto Costo/Beneficio quanto meno "neutro"

-Forse riduzione morbilità neurologica (5/23 CCHD non diagnosticate)

- Potenzialità della combinazione PI + SpO2 nello screening Neonatale precoce delle DDHD

Ringraziamenti

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James Roff

Luciano Bassani


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