

# Outcomes in paediatric anaesthesia: what should we measure?



**Walid Habre, MD, PhD**  
Anesthesiological Investigations Unit  
& Pediatric Anesthesia Unit  
Geneva University Children's Hospital



[www.walidhabre.org](http://www.walidhabre.org)



**UNIVERSITÉ  
DE GENÈVE**

**FACULTÉ DE MÉDECINE**

**I have no COI to declare**

# For 2 decades we were blinded by various outcomes

| <b>Neurocognitive Outcomes<br/>(Subdomain/Subprocess)</b> | <b>Domains</b>                       | <b>Assessment Instruments</b>                       |
|---|--------------------------------------|---|
| <b>1. Global cognitive function (IQ)</b>                  | <b>Global Cognitive Function</b>     | <b>1. WASI</b>                                      |
| <b>2. Visual memory</b>                                   | <b>Memory/Learning</b>               | <b>2. Faces, Delayed Faces (NEPSY II)</b>           |
| <b>3. Verbal memory</b>                                   |                                      | <b>3. CVLT-C</b>                                    |
| <b>4. Motor speed &amp; dexterity</b>                     | <b>Motor/Processing Speed</b>        | <b>4. Grooved Pegboard</b>                          |
| <b>5. Processing speed</b>                                |                                      | <b>5. Coding (WISC-IV)</b>                          |
| <b>6. Visuospatial function</b>                           | <b>Visuospatial</b>                  | <b>6. Block Design, Matrix Reasoning (WASI)</b>     |
| <b>7. EF components</b>                                   | <b>Attention/ Executive Function</b> | <b>7. BRIEF</b>                                     |
| <b>8. Working memory</b>                                  |                                      | <b>8. Digit Span (WISC-IV)</b>                      |
| <b>9. Sustained and selective attention, impulsivity</b>  |                                      | <b>9. CPT II</b>                                    |
| <b>10. Cognitive flexibility</b>                          |                                      | <b>10. DKEFS Trails Making</b>                      |
| <b>11. Verbal fluency</b>                                 |                                      | <b>11. Word Generation (NEPSY II)</b>               |
| <b>12. Expressive vocabulary</b>                          | <b>Language</b>                      | <b>12. Similarities (WASI)</b>                      |
| <b>13. Verbal reasoning</b>                               |                                      | <b>13. Vocabulary (WASI)</b>                        |
| <b>14. Receptive language</b>                             |                                      | <b>14. Comprehension of Instructions (NEPSY II)</b> |
| <b>15. Speeded naming</b>                                 |                                      | <b>15. Speeded Naming (NEPSY II)</b>                |
| <b>16. Internalizing behaviors</b>                        | <b>Behavior</b>                      | <b>16. CBCL Internalizing Scale</b>                 |
| <b>17. Externalizing behaviors</b>                        |                                      | <b>17. CBCL Externalizing Scale</b>                 |
| <b>18. DSM-oriented behaviors</b>                         |                                      | <b>18. CBCL. DSM-oriented Scales</b>                |
| <b>19. Adaptive behavior function</b>                     |                                      | <b>19. ABAS II</b>                                  |

| Psychometric test | Domain of testing   | Domain of testing                          |
|-------------------|---|--|
| ABAS-II           | Adaptive Behavior Assessment System—2nd Edition                                       | Development                                |
| AIMS              | Alberta Infant Motor Scale  | Development                                |
| —                 | Albert Einstein College of Medicine Neonatal Neurobehavioral Assessment Scale         | Development                                |
| AVLT              | Rey Auditory Verbal Learning Test   | Intelligence/cognition                     |
| ASQ               | Ages & Stages Questionnaire   | Development                                |
| BDS               | Backward digit span test  | Intelligence/cognition                     |
| BRIEF             | Behavior Rating Inventory of Executive Functions                                      | Development                                |
| BSID-II           | Bayley Scales of Infant and Toddler Development—2nd Edition                           | Development intelligence                   |
| BSID-III          | Bayley Scales of Infant and Toddler Development—3rd Edition                           | Development intelligence                   |
| CAT               | California Achievement Test   | Academic achievement                       |
| CBCL              | Child Behavior Checklist  | Development                                |
| CDI               | Child Depression Inventory  | Screening/diagnosis (psychiatric disorder) |
| CELF              | Clinical Evaluation of Language Fundamentals  | Development                                |
| CELF-E            | Clinical Evaluation of Language Fundamentals—expressive language score                | Development                                |
| CELF-R            | Clinical Evaluation of Language Fundamentals—receptive language score                 | Development                                |
| CELF-T            | Clinical Evaluation of Language Fundamentals—total language ability                   | Development                                |
| CHQ50             | The Child Health Questionnaire 50   | Development                                |
| CPM               | Raven's Colored Progressive Matrices  | Intelligence/cognition                     |
| CPT-II            | Continuous Performance Test II  | Development                                |
| CTRS-R            | Conners' teacher Rating Scale—Revised   | Development                                |
| CVLT-C            | California Verbal Learning Test—Children  | Academic achievement                       |
| DKEFS             | Delis-Kaplan Executive Function Systems/Trail Making Subtests                         | Academic achievement                       |
| DSM-IV            | Diagnostic and Statistical Manual of Mental Disorders—4th Edition                     | Screening/diagnosis (psychiatric disorder) |
| DSM-ADH           | DSM—attention deficit hyperactivity scores  | Screening/diagnosis (psychiatric disorder) |
| EDI               | Early Development Instrument  | Development                                |
| FDS               | Forward digit span test   | Intelligence/cognition                     |
| FSIQ              | Full scale intelligence-quotient  | Intelligence/cognition                     |
| G-TVPS            | Gardner Test of Visual-Perceptual Skills Revised                                      | Development                                |
| GDQ               | General Developmental Quotient  | Development                                |
| GDS               | Gesell Developmental Schedule   | Development                                |
| GMDS              | Griffiths Mental Development Scale  | Development                                |
| GMFCS             | General Motor Function Classification Score   | Development                                |
| HAWIVA-III        | Hannover-Wechsler Intelligence Scale, 3rd Edition                                     | Intelligence/cognition                     |
| GPT               | Grooved Pegboard Test   | Development                                |
| ICD-9             | International classification of Diseases—9th—Attention Deficit Hyperactivity Disorder | Screening/diagnosis (psychiatric disorder) |
| ICD-9-CM 299.00   | International Classification of Diseases—9th—Autistic Disorder                        | Screening/diagnosis (psychiatric disorder) |
| ICD-9-CM 314.01   | International Classification of Diseases—9th—Attention Deficit Hyperactivity Disorder | Screening/diagnosis (psychiatric disorder) |
| IEP-EBD           | Individualised Education Program—Emotion Behavior Disorders                           | Academic achievement*                      |
| IEP-SL            | Individualised Education Program—Speech and Language                                  | Academic achievement*                      |
| K-ABC             | Kaufman Assessment Battery for Children   | Intelligence/cognition                     |
| KET-KID           | Kognitiv-Emotionale Test für das Kindergartenalter                                    | Intelligence/cognition                     |
| LD                | Learning Disabilities   | Screening/diagnosis                        |
| MAND              | McCarron Assessment of Neuromuscular Development                                      | Development                                |

Continued

## Systematic review of the neurocognitive outcomes used in studies of paediatric anaesthesia and neurotoxicity

N. G. Clausen<sup>1,2,3,\*</sup>, S. Kähler<sup>1</sup> and T. G. Hansson<sup>1</sup>

| Psychometric test                                      | Domain of testing | Domain of testing                      |
|--|-------------------|--|
| Inventory  | Development       | Development                            |
| Magnetic resonance imaging                             | Development       | Screening/diagnosis (somatic disorder) |
| Developmental Neuropsychological Assessment            | Development       | Academic achievement                   |
| NEPSY-2-NL   | Development       | Development                            |
| Battery  | Development       | Development                            |
| Otis-Intelligence Scales                               | Development       | Cognition                              |
| OWLS   | Development       | Academic achievement                   |
| PDMS   | Development       | Development                            |
| —  | Development       | Intelligence/cognition                 |
| PIQ  | Development       | Intelligence/cognition                 |
| PPVT   | Development       | Academic achievement                   |
| RDLs   | Development       | Development                            |
| PSLE   | Development       | Academic achievement                   |
| SDMT   | Development       | Development                            |
| SON-P  | Development       | Intelligence/cognition                 |
| —  | Development       | Intelligence/cognition                 |
| Stanford   | Development       | Academic achievement                   |
| Stanford-Binet Intelligence Scales—5th Edition         | Development       | Intelligence/cognition                 |
| Stroop Color and Word Test                             | Development       | Intelligence/cognition                 |
| Total Cognitive Skills                                 | Development       | Intelligence/cognition                 |
| Total Intelligence Quotient                            | Development       | Intelligence/cognition                 |
| Test of Everyday Attention for Children, Dutch version | Development       | Intelligence/cognition                 |
| Trail Making Test—part A                               | Development       | Intelligence/cognition                 |
| VABS   | Development       | Development                            |
| VIQ  | Development       | Intelligence/cognition                 |
| VMI  | Development       | Intelligence/cognition                 |
| Wallin BP  | Development       | Development                            |
| WAMSE  | Development       | Academic achievement                   |
| WASI   | Development       | Intelligence/cognition                 |
| WJ III   | Development       | Academic achievement                   |
| WJ III—Visual Matching                                 | Development       | Academic achievement                   |
| WeeFIM   | Development       | Development†                           |
| WPPSI-R  | Development       | Intelligence/cognition                 |
| WISC-III   | Development       | Intelligence/cognition                 |
| WISC-III-NL  | Development       | Intelligence/cognition                 |
| WISC-IV  | Development       | Intelligence/cognition                 |

Clausen NG et al. Br J Anaesth 2018; 120:1255

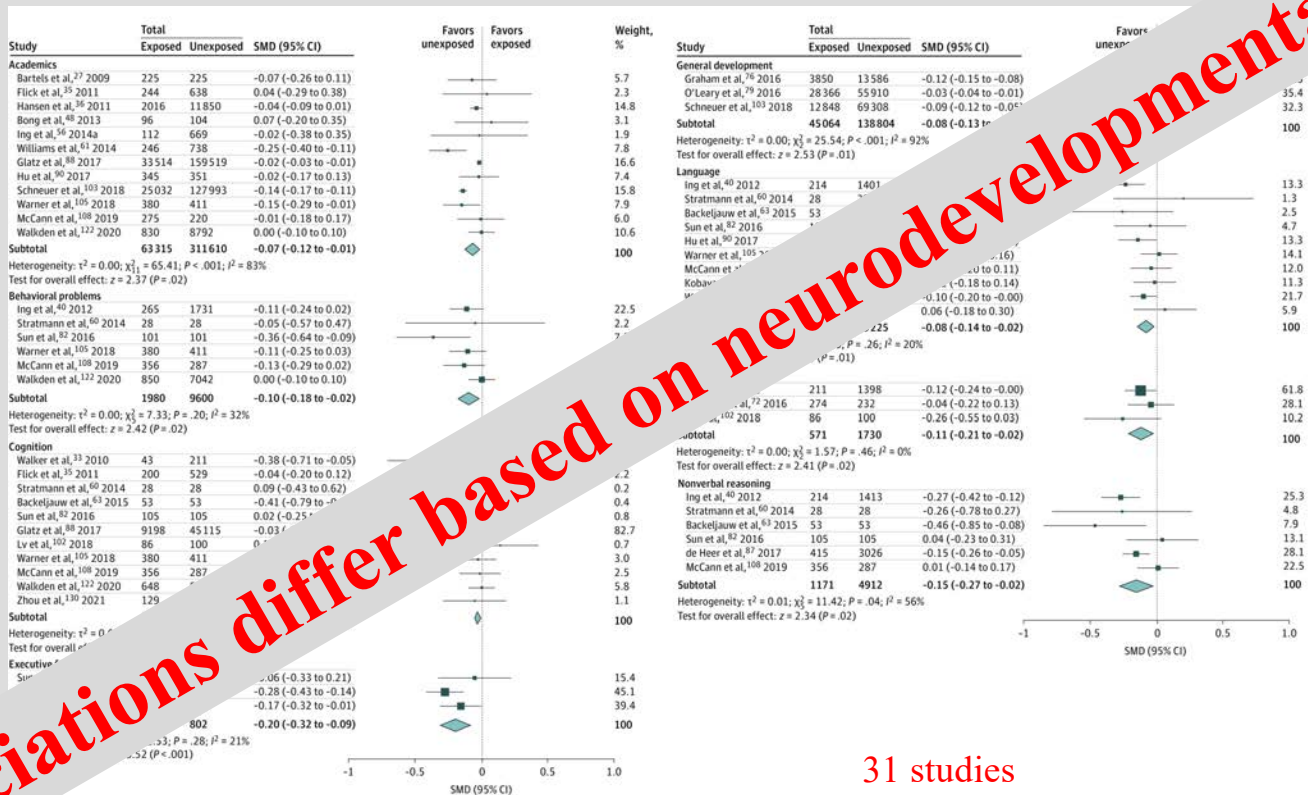
**67 studies included in qualitative analysis**

Systematic review of the neurocognitive outcomes  
used in studies of paediatric anaesthesia  
neurotoxicity

N. G. Clausen<sup>1,2,3,\*</sup>, S. Kähler<sup>1</sup> and T. G. Hansen<sup>1,2</sup>

The effect(s) of GA (and surgery) in young children have been assessed by **various outcome measures**. This variability in test items used reflects the problem that the **clinical presentation** of a potential damaging impact on young children's brains following GA/surgery **is not properly defined**.

# Association between exposure to GA and domain-specific neurodevelopmental outcomes in children: SR & meta-analysis



31 studies

# Neurotoxicity of anaesthetic drugs and neurodevelopment : an old story

- **All anaesthetic agents were involved in experimental studies**
- **Extrapolation to clinical findings is hazardous.**
- The **large clinical epidemiological studies** assessing potential association between anaesthesia before 3-4 yrs of age and language abnormalities or learning problems **are definitely reassuring**
- **The results of the trials: TWINS-PANDA-GAS sounded the death knell of the neurotoxicity of anaesthetics.**

# Anaesthesia is just a marker associated with potential neurodevelopmental alterations

## MULTIFACTORIAL

### Preoperative Factors

- Structural anomalies in the brain
- Severe acidosis, hypoxia & hypoxaemia, low cardiac output
- CHD: in the context of genetic syndromes (Di George, Down...)

### Intraoperative Factors

- Activation of inflammatory cascades (Surgery, CPB...)
- Emboli
- Hypothermia during CPB
- Hyperventilation and hypocapnia
- Hypoxaemia

### Postoperative Factors

- Hyperthermia, Hyperglycaemia
- Decrease in oxygen delivery
- LOS in PICU/NICU
- Pain, infection

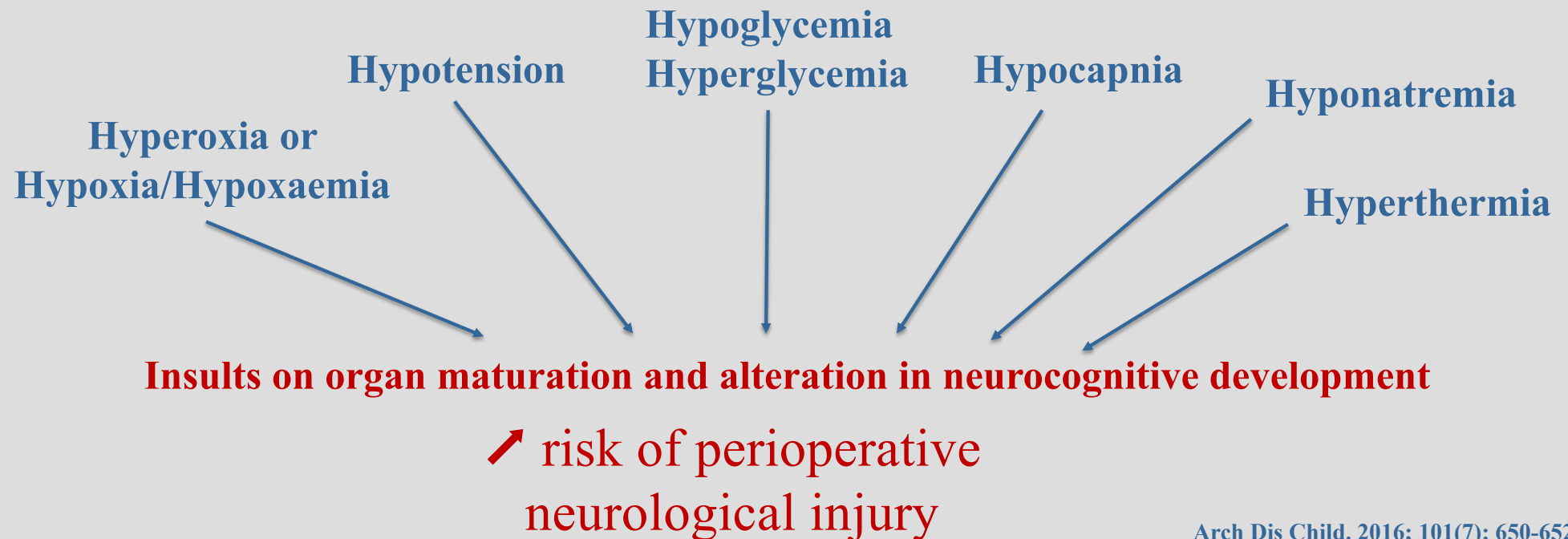


## Ensuring safe anaesthesia for neonates, infants and young children: what really matters

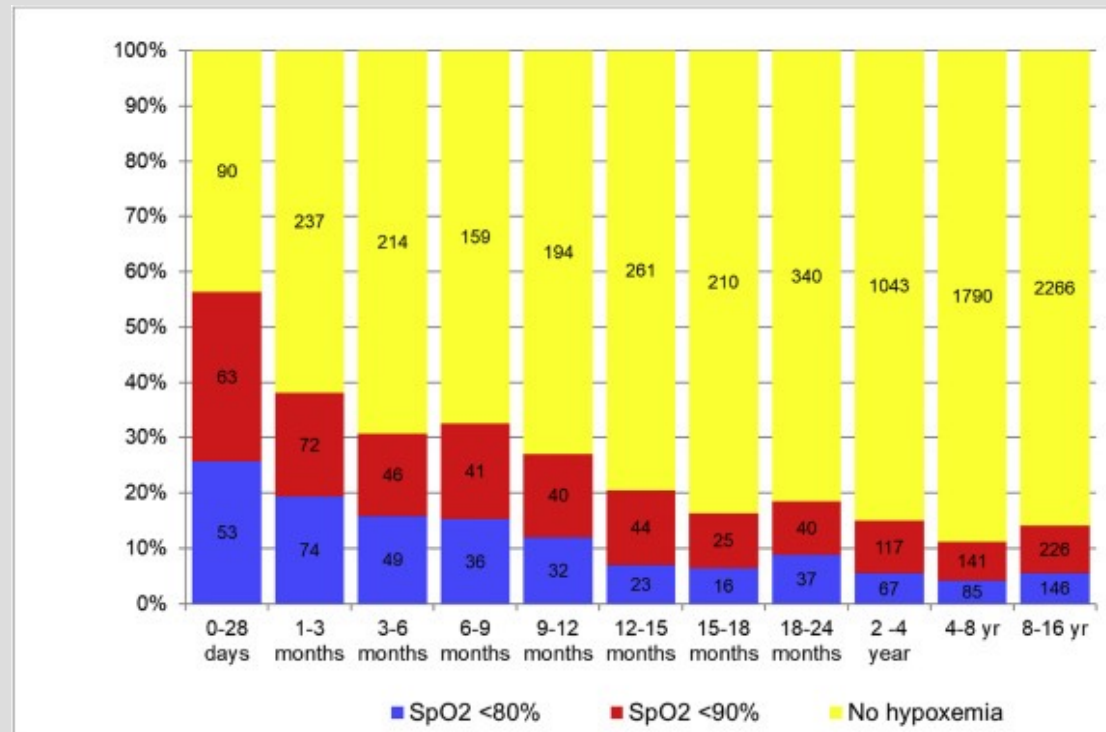
M Weiss,<sup>1,2</sup> T G Hansen,<sup>3,4</sup> T Engelhardt<sup>5</sup>

## Beyond Anesthesia Toxicity: Anesthetic Considerations to Lessen the Risk of Neonatal Neurological Injury

Mary Ellen McCann, MD,\* Jennifer K. Lee, MD,† and Terrie Inder, MBChB‡



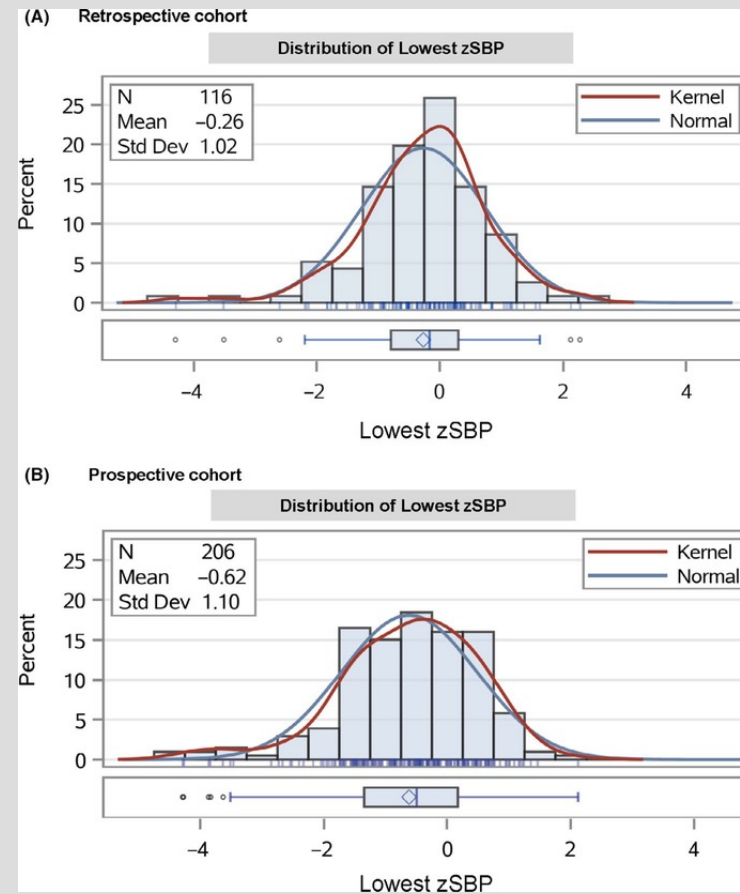
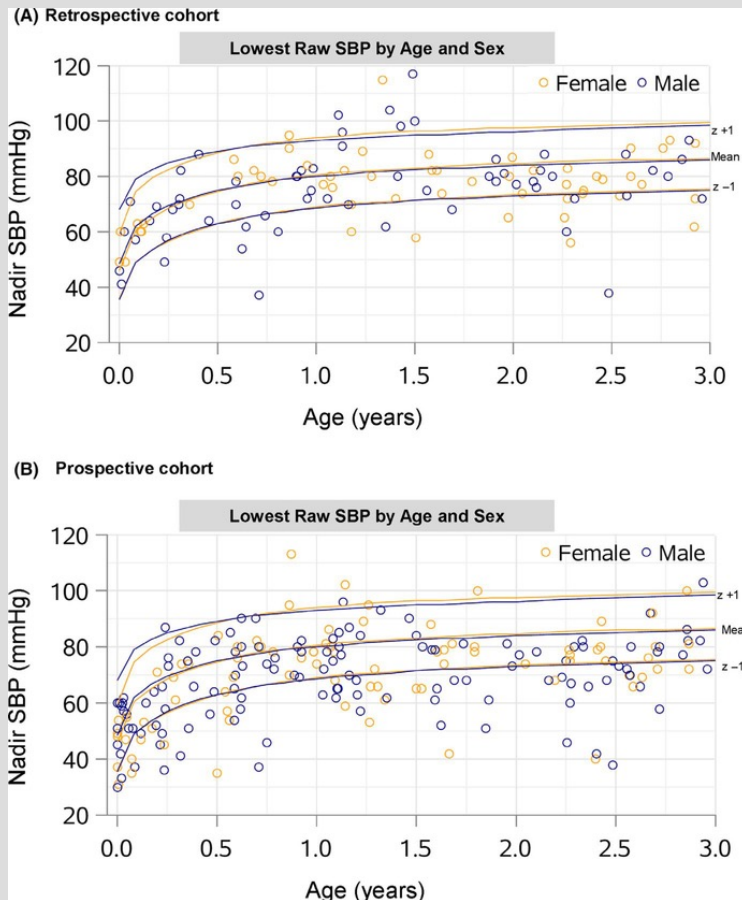
# Incidence of hypoxaemia in children



Percentage of cases with at least 1 period of hypoxemia for at least 1 min in relation to age group

# Hypotension and Neurodevelopment outcomes: secondary analysis

## Is there enough evidence to support the hypothesis ?



EDITORIAL

## **The rise and fall of anaesthesia-related neurotoxicity and the immature developing *human* brain**

T. G. Hansen<sup>1,2</sup> and P.-A. Lönnqvist<sup>3,4</sup>

**The skill and dedication of the anaesthetist is much more important than what drugs are being used**

Hansen TG et al. Acta Anaesthesiol Scand. 2016;60:280-3.

Weiss M et al. Curr Op Anaesthesiol 2015; 28: 302

## Perioperative factors affecting measured outcomes

- Perioperative physiologic disturbances: hypoxia, hypocapnia, hypercapnia, **hypotension**.
- **Inflammation**
- Psychologic stresses associated with surgery
- Underlying conditions necessitating surgery (i.e. confounding by indication).

**Which outcomes should we be looking for ?**

# Secondary Outcomes



- Risk factors for the occurrence of severe critical events
- **Outcomes of the critical events and 30-day in-hospital mortality**



**Morbidity and mortality** at 30 and 90 days  
**Risk factors** for interventions, morbidity and mortality



## Outcome at 30 days

- 96% discharged home
- 2.2% still in hospital
- 1.7% transferred to another center

**Postoperative Pediatric mortality at 30 days :**

**1 in 1000**

**0.097% (95% CI 0.066-0.139)**





## Incidence of severe critical events

|                              | Number      | Incidence   | 95%CI            |
|------------------------------|-------------|-------------|------------------|
| Laryngospasm                 | 368         | 1.2%        | 1.1 – 1.3        |
| Bronchospasm                 | 371         | 1.2%        | 1.1 – 1.3        |
| Bronchial aspiration         | 29          | 0.1%        | 0.06 – 0.13      |
| Postanaesthetic Stridor      | 208         | 1.1%        | 0.9– 1.3         |
| Anaphylaxis                  | 3           | 0.01%       | 0.002 – 0.025    |
| Cardiovascular instability   | 549         | 1.9%        | 1.7 – 2.0        |
| Cardiac arrest               | 10          | 0.03%       | 0.01 – 0.05      |
| Neurological damage          | 5           | 0.02%       | 0.002 – 0.03     |
| Drug error                   | 49          | 0.2%        | 0.1 – 0.2        |
| <b>Overall (any of them)</b> | <b>1637</b> | <b>5.3%</b> | <b>5.0 – 5.5</b> |



## Incidence morbidity and mortality

|  | 30-Day Morbidity     | 30- & 90-day Mortality |
|--|----------------------|------------------------|
| <b>Entire Cohort</b>                               | <b>17% (16 - 18)</b> | <b>3.2% (2.7-3.7)</b>  |
| Surgeries (non-cardiac)                            | 0.14 (0.13 - 0.15)   | 0.024 (0.02 - 0.029)   |
| Cardiac surgery                                    | 0.52 (0.46 - 0.57)   | 0.095 (0.06 - 0.13)    |
| Non-surgical procedure<br>(excluding cardiac cath) | 0.18 (0.15 - 0.20)   | 0.042 (0.03 - 0.06)    |
| Cardiac catheterism                                | 0.15 (0.07 - 0.27)   | 0.06 (0.01 - 0.16)     |

Incidence and 95% Confidence Interval



## Overall incidence of critical events requiring intervention

**35.3% (95%CI: 34.1-36.4)**



# Impact of composite adverse event

## Hypotension, Hypoxaemia and Anaemia



↑ Morbidity (**RR 3.56** [95%CI: 1.64-7.71])

↑ Mortality (**RR 19.80** [95% CI 5.87-66.73])

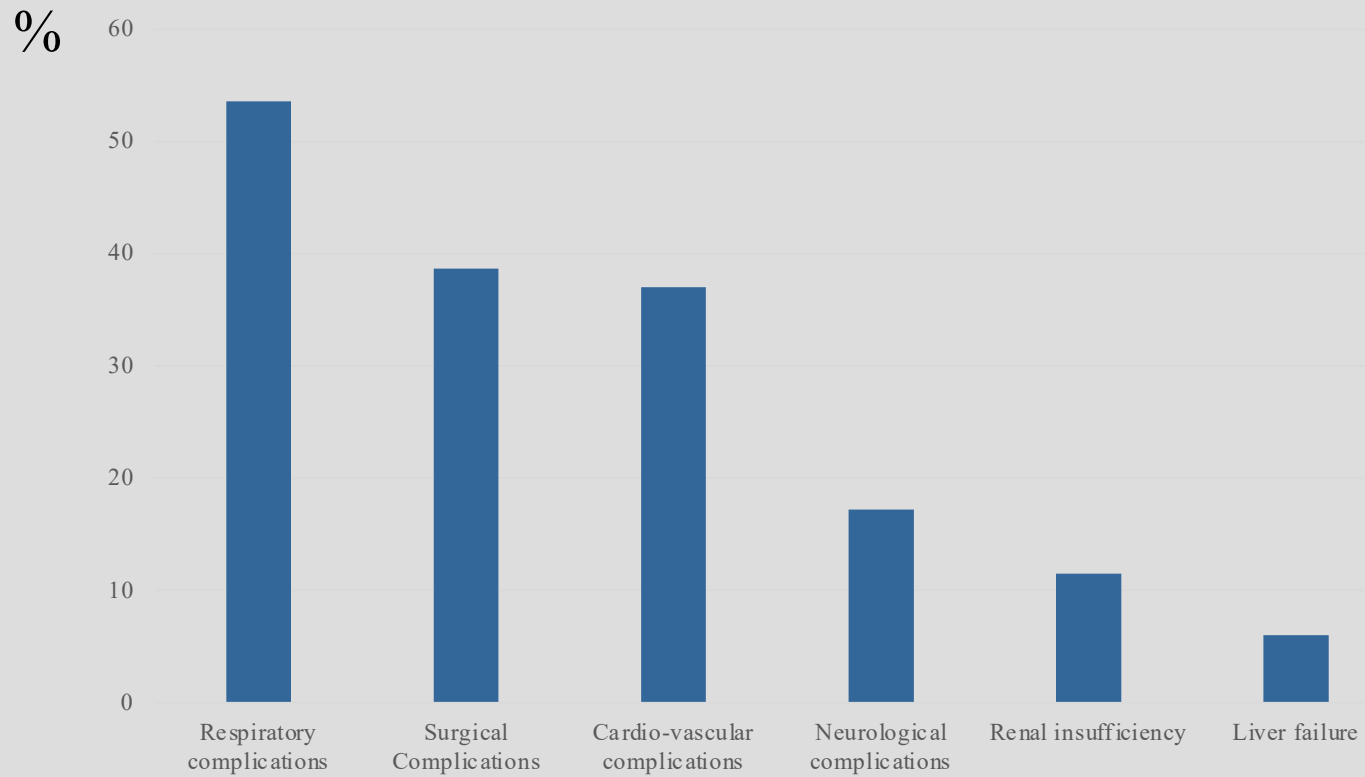
**OUTCOMES**  
**Secondary endpoints**



|                                     | <b>Outcomes</b>                             | <b>n</b> | <b>%</b>          |
|-------------------------------------|---|----------|-------------------|
| <b>Laryngospasm</b>                 | Uneventful                                  | 358      | 97·1              |
|                                     | <b>Prolonged intubation</b>                 | 9        | <b>2·4</b>        |
|                                     | Pulmonary oedema                            | 1        | <b>0·3</b>        |
| <b>Bronchospasm</b>                 | Uneventful                                  | 216      | 57·1              |
|                                     | <b>Hypoxemia (&lt; 90%)</b>                 | 145      | <b>38·4</b>       |
|                                     | Prolonged intubation/ICU admission          | 13       | <b>3·5</b>        |
| <b>Bronchial aspiration</b>         | Uneventful                                  | 18       | 54·6              |
|                                     | <b>Prolonged intubation</b>                 | <b>4</b> | <b>12·1</b>       |
|                                     | <b>Hypoxaemia / Pneumonia</b>               | 10 / 1   | <b>30·3 / 3·0</b> |
| <b>Stridor</b>                      | Uneventful                                  | 198      | 95·2              |
|                                     | <b>Intubation /Tracheostomy</b>             | 9 / 1    | <b>4·3 / 0·5</b>  |
| <b>Severe cardiovascular events</b> | Uneventful                                  | 560      | 94                |
|                                     | <b>Cardiac arrest</b>                       | <b>8</b> | <b>1·3</b>        |
|                                     | Coagulopathy                                | 19       | <b>3·2</b>        |
|                                     | Other: (ECMO - Myocardial ischemia          | 9        | <b>1·5</b>        |
|                                     | ICU admission - Reoperation for haemostasis |          |                   |
| <b>Drug errors</b>                  | No sequelae                                 | 15       | 31·2              |
|                                     | Minor sequelae                              | 32       | 66·7              |
|                                     | <b>Major sequelae-Admission ICU</b>         | <b>1</b> | <b>2·1</b>        |



## Causes of morbidity at 30 days





## Risk factors for complications at 30 days

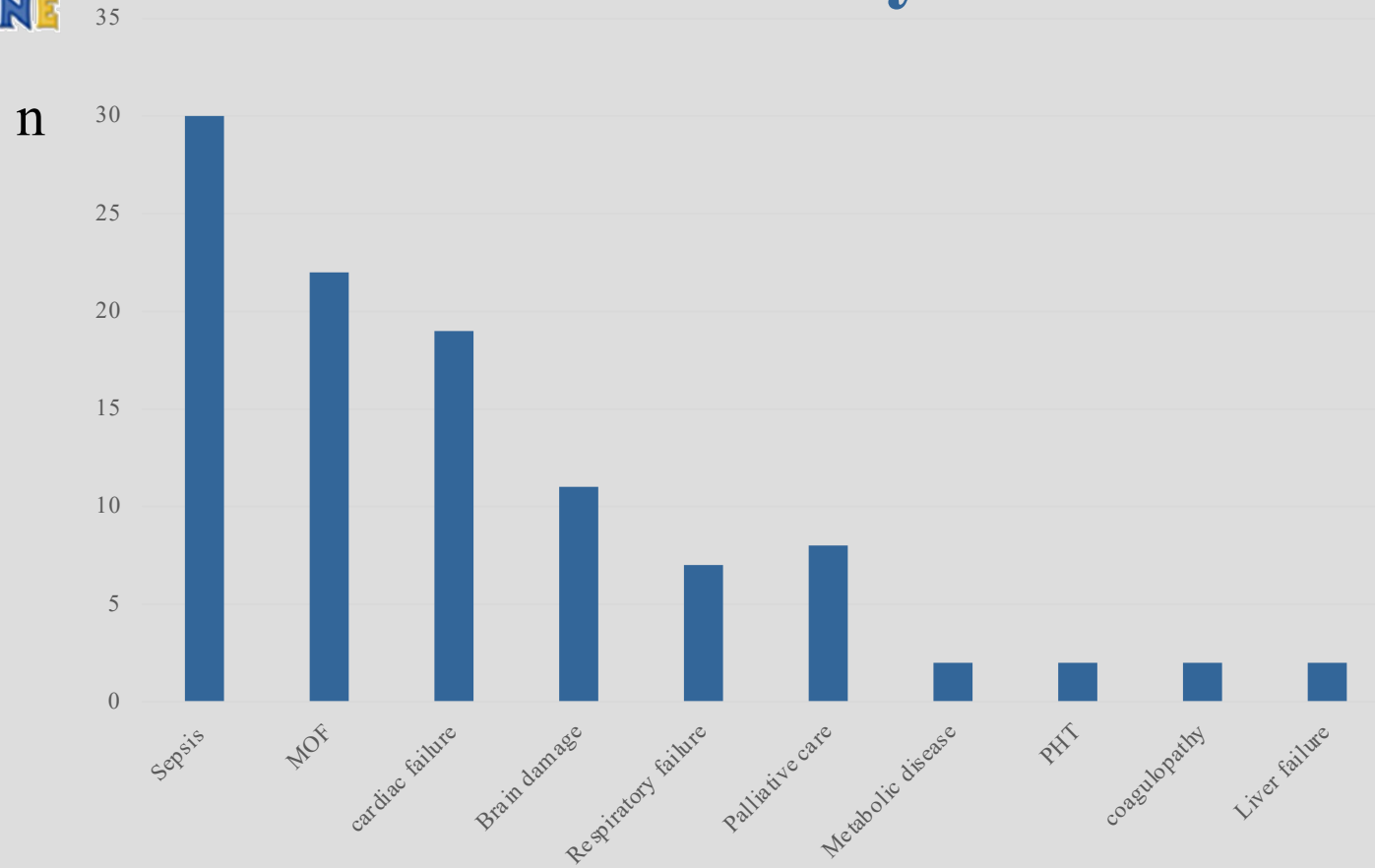
|   | RR          | 95% CI             |
|---|-------------|--------------------|
| <b>Weight at inclusion</b>  | <b>0.84</b> | <b>0.79 - 0.90</b> |
| <b>Neonatal medical history</b>   | 1.56        | 1.19 - 2.05        |
| <b>Preoperative intensive support</b><br>(Cardio-vase support, admission from ICU, ASA III-V) | <b>2.55</b> | <b>2.02 - 3.23</b> |
| <b>Current comorbidities</b>  | <b>1.52</b> | <b>1.27 - 1.80</b> |
| <b>Unplanned intraoperative interventions</b>   | 1.19        | 1.06 - 1.35        |
| <b>Length of surgery</b>  | 1.12        | 1.08 - 1.18        |

Multivariable analysis (n = 6072), controlling for cardiac surgery and multiple procedures with the participating center as a random factor





## Causes of mortality at 30/90 days





## Risk factors associated with mortality at 30 & 90 days

|   | RR          | 95% CI              |
|---|-------------|---------------------|
| <b>Weight at inclusion</b>  | <b>0.74</b> | <b>0.62 - 0.88</b>  |
| <b>Preoperative intensive support</b><br>(Cardio-vasc support, admission from ICU, ASA III-V) | <b>6.83</b> | <b>3.08 – 15.03</b> |
| <b>Current comorbidities</b>  | <b>2.29</b> | <b>1.33 – 3.95</b>  |
| <b>Surgical plan</b><br>(urgent/emergency or after hours or location of procedure: ICU)       | <b>2.09</b> | <b>1.32 – 3.29</b>  |
| <b>Surgical revision for postoperative bleeding</b>   | <b>7.71</b> | <b>4.51 – 13.18</b> |

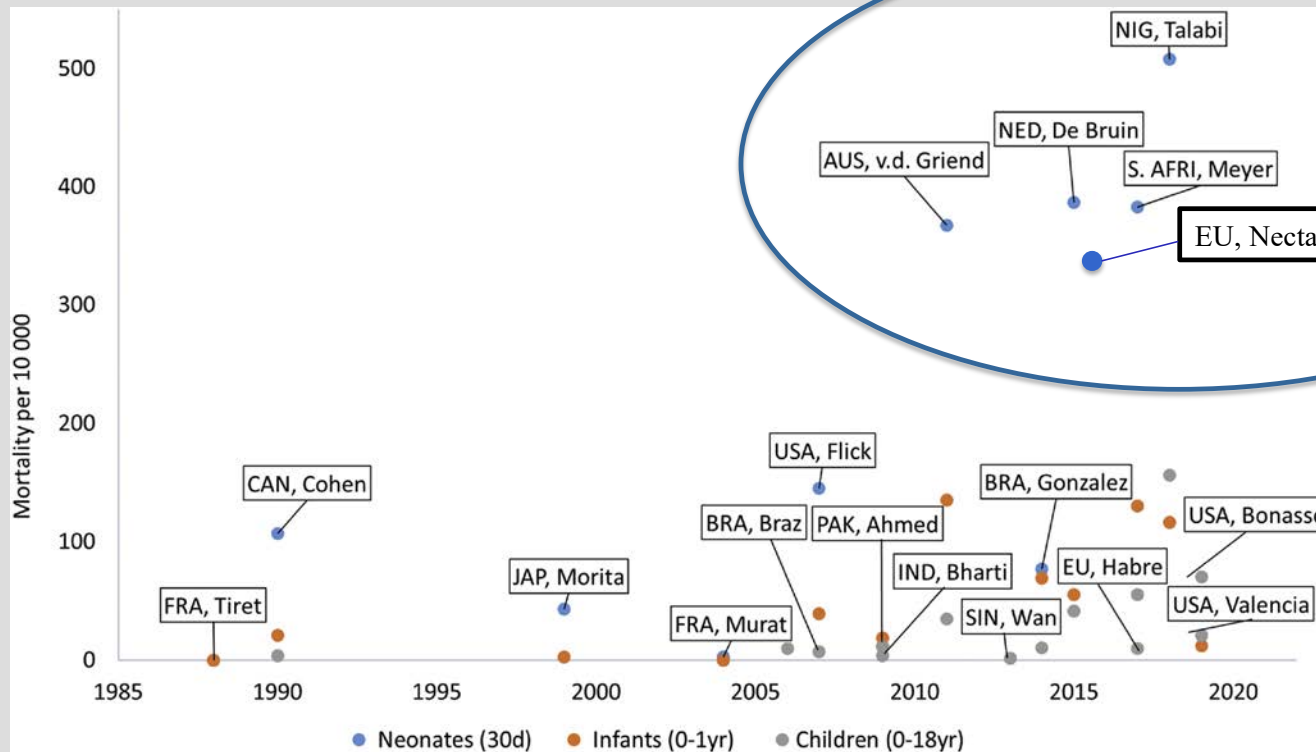
Multivariable analysis (n = 6072), controlling for cardiac surgery and multiple procedures with the participating center as a random factor

# Serious adverse events from Wake Up Safe initiative

|                        | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | # Events (% total events) | Overall rate in 1 964 211 patients<br>Adverse events/100 000 pts |
|------------------------|------|------|------|------|------|------|---------------------------|--|
| Airway injury          | 1    | 2    | 3    | 3    | 3    | 4    | 16 (2.1)                  | 0.08   |
| Airway management      | 0    | 3    | 6    | 6    | 6    | 9    | 30 (4)                    | 0.15   |
| Awareness              | 0    | 2    | 0    | 1    | 3    | 1    | 7 (0.9)                   | 0.04   |
| Blood transfusion      | 1    | 3    | 1    | 2    | 0    | 0    | 7 (0.9)                   | 0.04   |
| Cardiovascular support | 2    | 12   | 6    | 4    | 1    | 5    | 30 (4)                    | 0.15   |
| Musculocutaneous       | 0    | 3    | 5    | 3    | 6    | 3    | 20 (2.7)                  | 0.10   |
| Equipment issues       | 2    | 3    | 3    | 3    | 4    | 8    | 23 (3.1)                  | 0.12   |
| Eye injury             | 0    | 4    | 2    | 5    | 1    | 2    | 14 (1.9)                  | 0.07   |
| Medication events      | 22   | 33   | 56   | 48   | 33   | 47   | 239 (31.9)                | 1.22   |
| Perioperative death    | 0    | 0    | 0    | 0    | 1    | 1    | 2 (2.9)                   | 0.01   |
| Other                  | 1    | 10   | 7    | 8    | 6    | 3    | 35 (4.7)                  | 0.18   |
| Respiratory events     | 5    | 40   | 23   | 26   | 35   | 52   | 181 (24.1)                | 0.92   |
| Cardiac arrest         | 16   | 22   | 13   | 24   | 32   | 32   | 139 (18.5)                | 0.71   |
| Neurological injury    | 0    | 1    | 4    | 0    | 1    | 1    | 7 (0.9)                   | 0.04   |
| Total                  | 50   | 138  | 129  | 133  | 132  | 168  | 750                       | 3.82   |

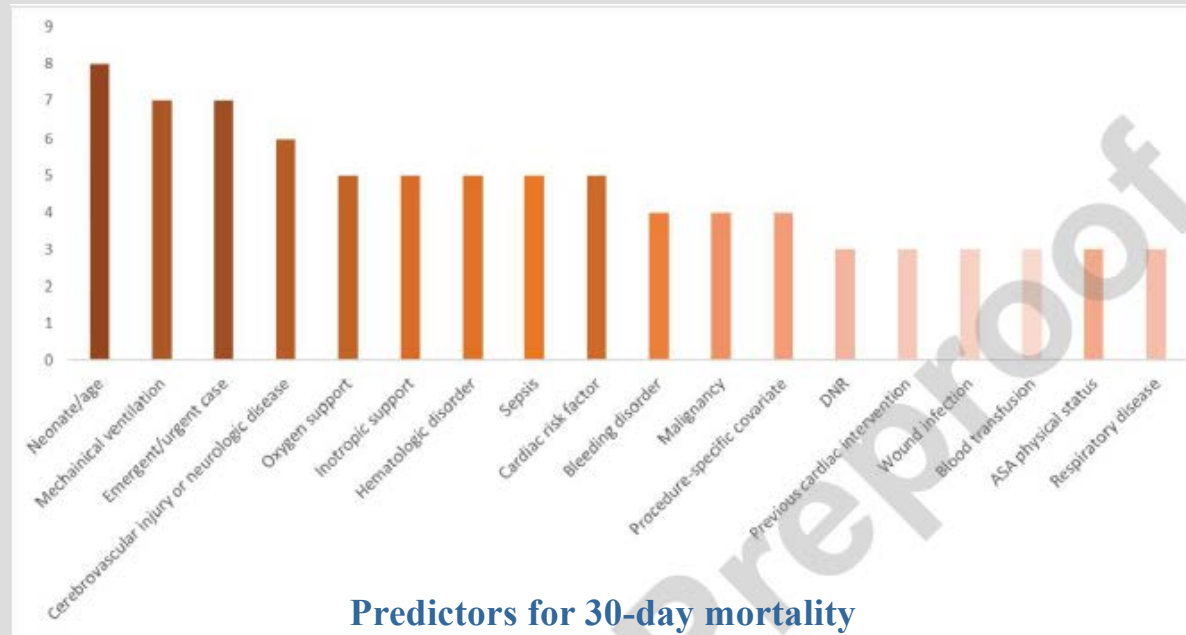
85% preventable

# Incidence of 30-day mortality in children



Neonates

# Prediction of mortality in the paediatric population systematic review of risk assessment tools



9 of the 10 studies describe risk scores of 30-day mortality  
None addressed risk score for intra-operative mortality  
One single study focused on external validation

# Development of a Paediatric Risk Assessment score to predict perioperative mortality in children undergoing noncardiac surgery

| Variables                | B (SE)      | OR   | 95% CI    | P     |
|--------------------------|-------------|------|-----------|-------|
| Hematologic disorders    | 0.47 (0.10) | 1.60 | 1.32–1.93 | <.001 |
| Preoperative transfusion | 0.54 (0.11) | 1.71 | 1.38–2.11 | <.001 |
| Congenital heart disease | 0.64 (0.09) | 1.89 | 1.58–2.25 | <.001 |
| Neurologic disease       | 0.69 (0.08) | 2.00 | 1.71–2.34 | <.001 |
| Urgent                   | 0.80 (0.08) | 2.22 | 1.90–2.61 | <.001 |
| Respiratory disease      | 0.89 (0.10) | 2.43 | 1.99–2.96 | <.001 |
| Preoperative CPR         | 1.00 (0.17) | 2.71 | 1.93–3.82 | <.001 |
| Acute kidney injury      | 1.08 (0.23) | 2.95 | 1.85–4.71 | <.001 |
| Chemotherapy             | 1.08 (0.24) | 2.96 | 1.85–4.71 | <.001 |
| Inotropic support        | 1.42 (0.11) | 4.13 | 3.35–50.9 | <.001 |
| Age < 12 mo              | 1.47 (0.10) | 4.34 | 3.55–5.30 | <.001 |
| Mechanical ventilation   | 1.93 (0.13) | 6.12 | 4.95–7.57 | <.001 |
| Neoplasm                 | 1.95 (0.16) | 7.02 | 5.14–9.57 | <.001 |

Data are obtained from multivariable logistic regression and presented as regression coefficient (B) (SE) and OR (95% CI) and Wald test *P* value.

Abbreviations: CI, confidence interval; CPR, cardiopulmonary resuscitation; OR, odds ratio; SE, standard error.

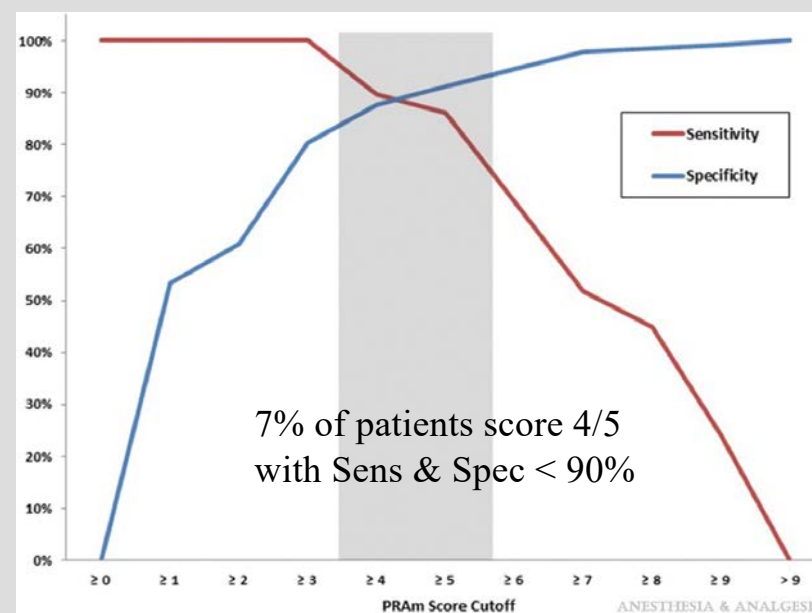
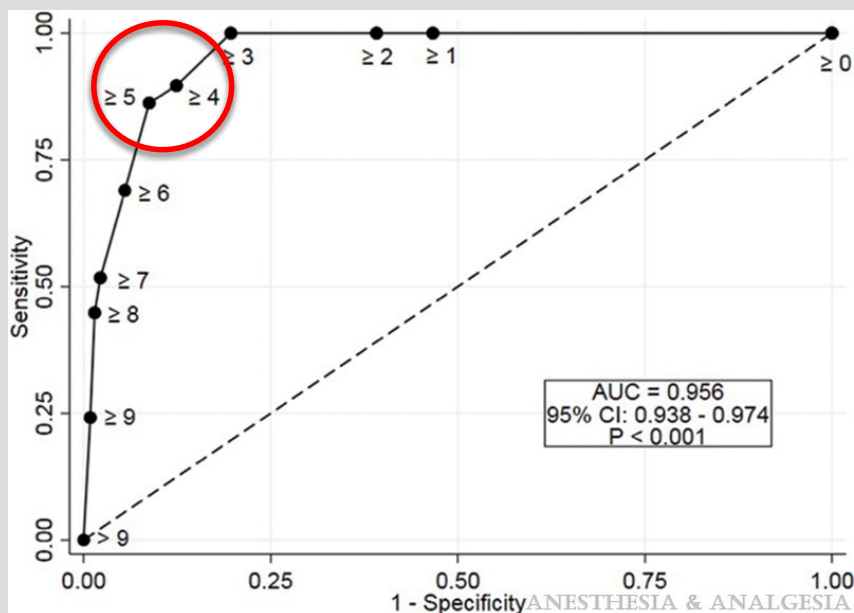
ANESTHESIA & ANALGESIA

| Variables      | Definition   | Value |
|----------------|--|-------|
| Urgent         | Urgent surgical procedure  | +1    |
| Comorbidity    | The presence of at least 1 comorbidity among the following: respiratory disease, congenital heart disease, preoperative acute or chronic kidney disease, neurologic disease, hematologic disease | +2    |
| Critically ill | The presence of at least 1 of the following characteristics of critical illness: preoperative mechanical ventilation, inotropic support, preoperative cardiopulmonary resuscitation              | +3    |
| Age <12 mo     | Age at the time of the surgical procedure <12 mo   | +3    |
| Neoplasm       | Surgical procedure in a patient with a neoplasm with or without preoperative chemotherapy  | +4    |

Abbreviation: PRAM, Pediatric Risk Assessment.

ANESTHESIA & ANALGESIA

# PRAm score: a simple and objective tool that predicts 30-day mortality in paediatric patients



| Variables      | Definition   | Value |
|----------------|--|-------|
| Urgent         | Urgent surgical procedure  | +1    |
| Comorbidity    | The presence of at least 1 comorbidity among the following: respiratory disease, congenital heart disease, preoperative acute or chronic kidney disease, neurologic disease, hematologic disease | +2    |
| Critically ill | The presence of at least one of the following characteristics of critical illness: preoperative mechanical ventilation, inotropic support, preoperative cardiopulmonary resuscitation            | +3    |
| Age <12 mo     | Age at the time of the surgical procedure <12 mo   | +3    |
| Neoplasm       | Surgical procedure in a patient with a neoplasm with or without preoperative chemotherapy  | +4    |

**Incidence of 30-day mortality:  
0.21% (29/13,530).**

**What about the most important Outcome ?**  
**Quality**



# **Setting a universal standard: Should we benchmark quality outcomes for pediatric anesthesia care?**

**The time has come to move beyond mortality and establish universally accepted minimum outcome standards in pediatric anesthesia. We believe this will ultimately improve confidence in the quality of pediatric anesthesia care offered to children, no matter where they are receiving that care.**

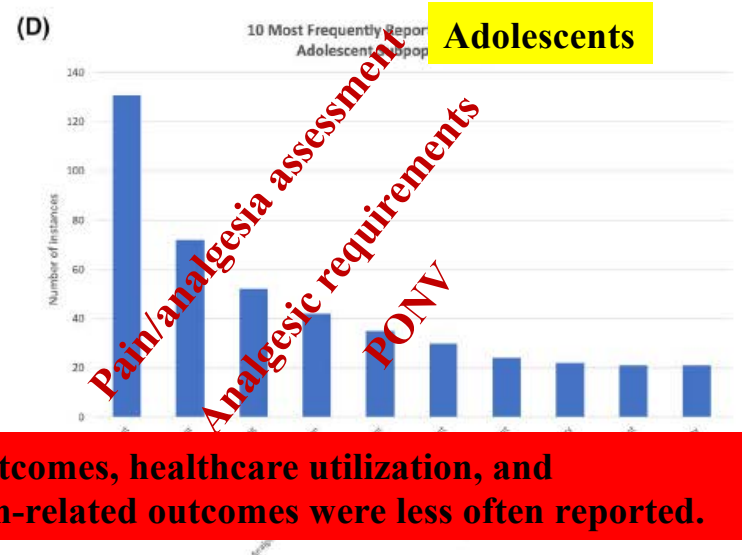
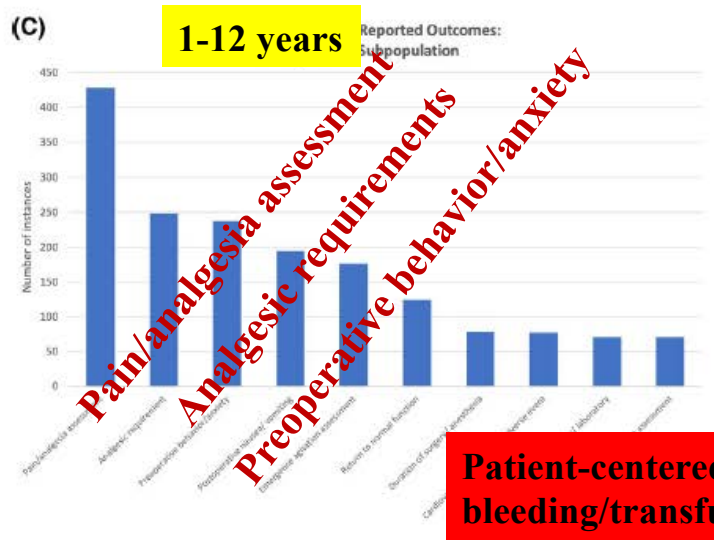
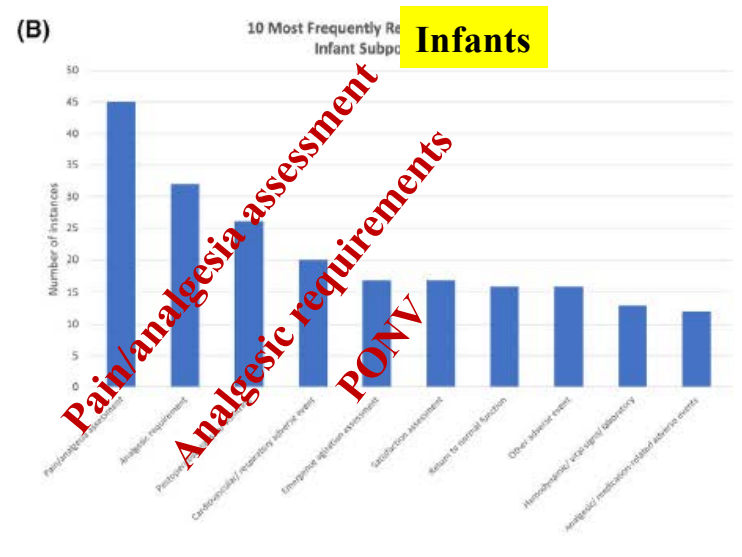
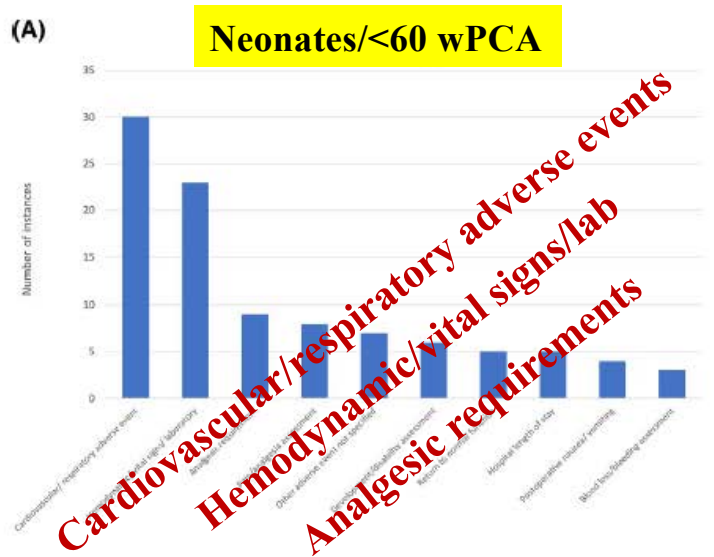
# A systematic review of outcomes reported in pediatric perioperative research: A report from the PPOG

Systematic review of pediatric **perioperative controlled trials** published over a recent 11-year period

**724 articles reporting 3192 outcome measures**



**Outcomes identified to be evaluated as candidates for inclusion in age-specific core outcome sets in subsequent phases of the pediatric perioperative outcome project**



**Patient-centered outcomes, healthcare utilization, and bleeding/transfusion-related outcomes were less often reported.**

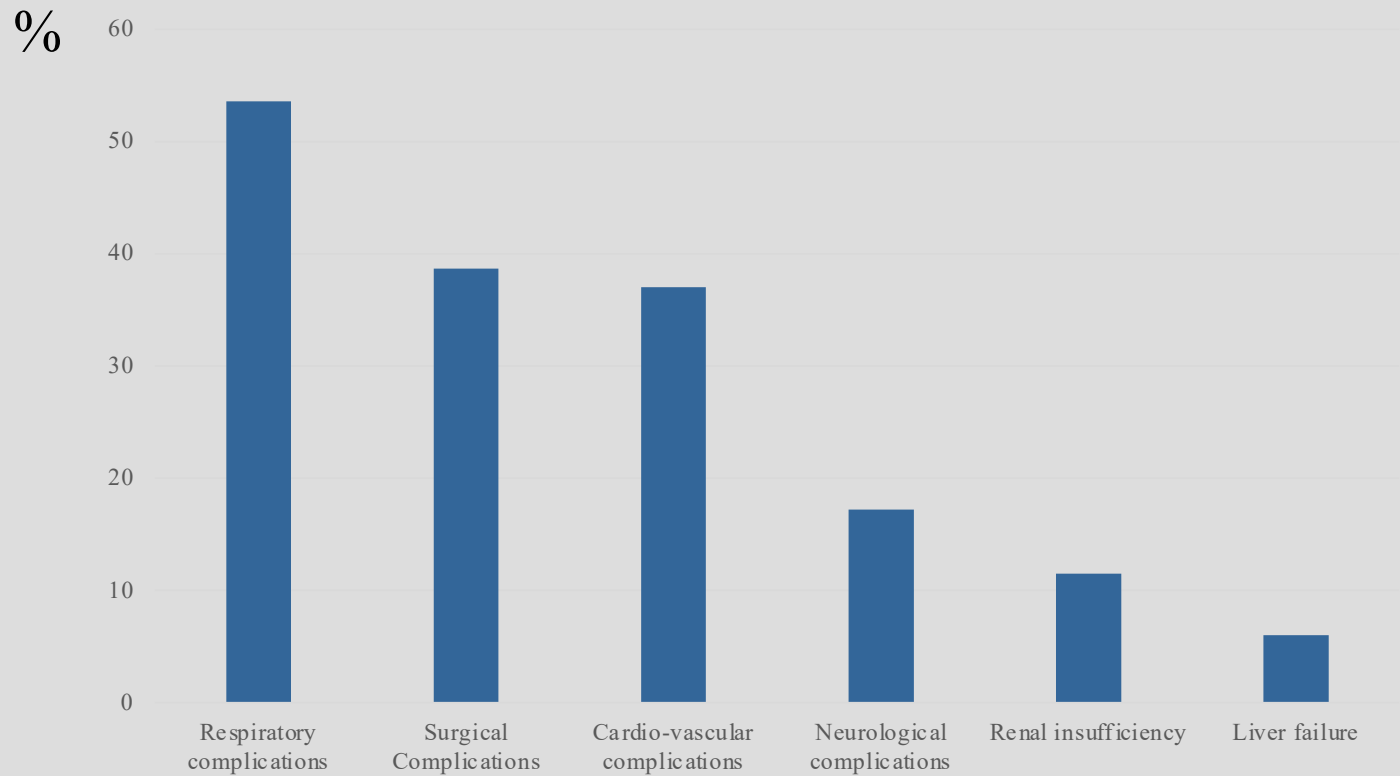
# Potential metrics for quality outcomes in paediatric anaesthesia

| Dimensions           | Suggested measures   |
|----------------------|--|
| Safety               | <p>Intraoperative cardiac arrest.</p> <p>Unplanned tracheal reintubation within 24 h of anaesthesia.</p> <p>Unplanned intensive care unit (ICU) admission within 24 h of anaesthesia.</p> <p>Unplanned hospital readmission for outpatient surgery.</p> <p>Activation of rapid response team within 24 h of anaesthesia.</p> <p>Death within 72 h of anaesthesia.</p> <p>Medication error.</p> |
| Effectiveness        | <p>Length of postoperative tracheal intubation (cardiac surgery, neonates).</p> <p>Length of postanesthesia care unit stay <math>\geq 120</math> min.</p> <p>Prolonged untreated or undertreated pain as indicated by high postoperative pain scores.</p> <p>Postoperative nausea or vomiting requiring rescue therapy.</p> <p>Failed regional anesthetic technique.</p>                       |
| Efficiency           | <p>On time 1st case starts in the operating room.</p> <p>Surgery start delay <math>\geq 60</math> min.</p> <p>Time from end of surgery to tracheal extubation.</p> <p>Operating room turnover time classified as time patient leaves the room to start of the next scheduled case.</p> <p>Same day case cancellation.</p>  |
| Equity               | <p>Consistent outcomes regardless of race, ethnicity, gender, socioeconomic status, etc.</p> <p>Equal adherence to standardized protocols between groups</p>   |
| Timeliness           | <p>Percent of emergent cases arriving to the OR from the ER within 60 min.</p>   |
| Patient-Centeredness | <p>Patient satisfaction survey scores.</p> <p>Postoperative satisfaction surveys.</p>  |

Olbrecht VA et al. Paediatr Anaesth 2022;32(8):892-898



# What about relevant clinical outcomes?



■ ORIGINAL CLINICAL RESEARCH REPORT

## **Acute Kidney Injury and Outcomes in Children Undergoing Noncardiac Surgery: A Propensity-Matched Analysis**

Theodora Wingert, MD, Tristan Grogan, MS, Maxime Cannesson, MD, PhD, Anil Sapru, MD, Wendy Ren, MD, FAAP, and Ira Hofer, MD

UCLA

## **Pediatric Acute Kidney Injury After Noncardiac Surgery: Another Vulnerable Population**

Douglas B. Atkinson, MD,\* and James A. DiNardo, MD†

Boston

# Population:

RETROSPECTIVE OBSERVATIONAL

## Inclusion:

All patients  $\leq 18$  years of age undergoing noncardiac surgery or procedures under anesthesia between April 2013 and January 2018 were considered eligible for inclusion if they had at least **1 preoperative serum creatinine (SCr) measurement within 1 year before the procedure.**

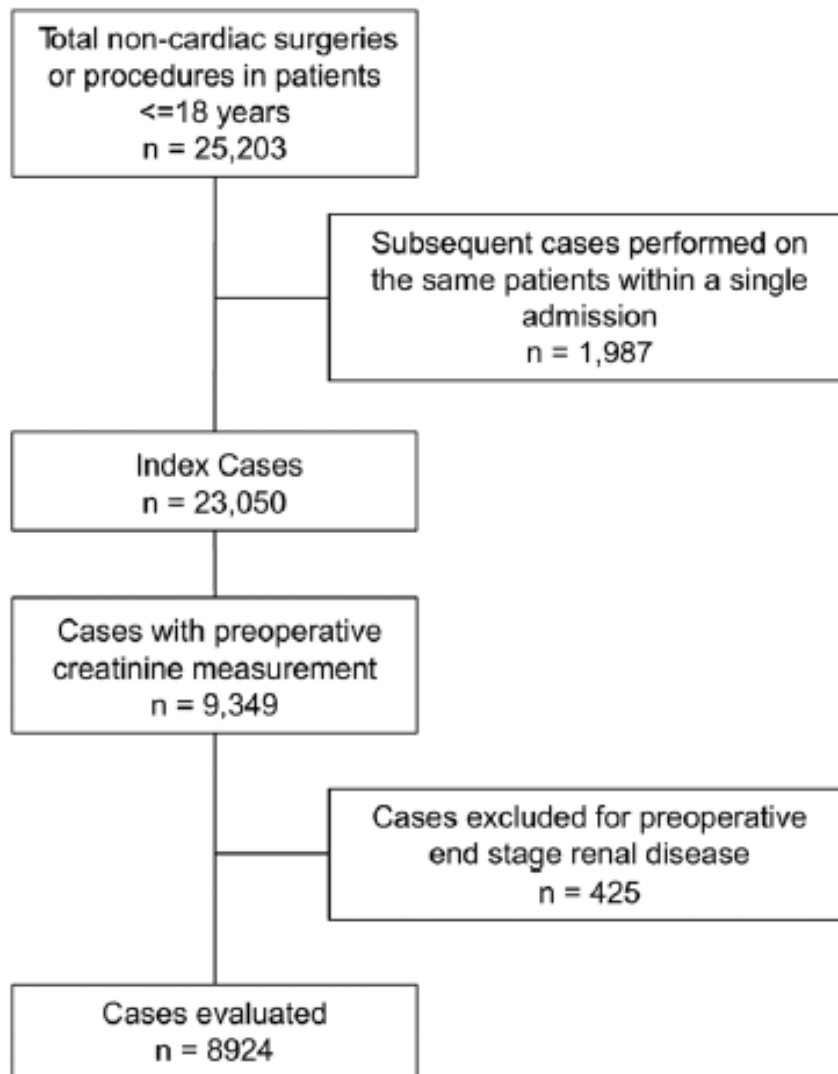
## Exclusion:

- Patients with end-stage renal disease (ESRD),
- preoperative need for renal replacement therapy (RRT),
- those undergoing central venous catheter placement specifically for the purpose of RRT

# Primary Outcome

- AKI defined by KDIGO group:
  - SCr the first 7 days postoperatively
- KDIGO stages of AKI:
  - SCr increase 1.5–1.9 times baseline or a  $\geq 0.3$  mg/ dL absolute increase (KDIGO stage 1),
  - SCr increase 2.0–2.9 times baseline (KDIGO stage 2),
  - SCr increase 3 times baseline or greater (KDIGO stage 3).
- Patients were also considered to have KDIGO stage 3 if Cr reached 4.0 mg/dL, estimated glomerular filtration rate (GFR) dropped  $<35$  mL/ min/1.73 m<sup>2</sup> , or new hemodialysis or new continuous RRT was initiated.





Prevalence: 3.2% of kids 95% CI (2.9-3.6)

- KDIGO stage 1: prevalence of 1.8%
- KDIGO stage 2: prevalence of 1.2%
- KDIGO stage 3: prevalence of 0.2%

|   | <b>No AKI<br/>N = 8636</b> | <b>Any Stage AKI<br/>N = 288</b> | <b>P Value</b> |
|---|----------------------------|----------------------------------|----------------|
| General anesthetic                            | 6094 (70.6%)               | 210 (72.9%)                      | .389           |
| Anesthesia duration, min                      | 169.71 (1538.9)            | 186.35 (164.1)                   | .857           |
| Intraoperative arterial line                  | 771 (8.9%)                 | 63 (21.9%)                       | <.001          |
| Intraoperative nephrotoxic antibiotic         | 649 (7.5%)                 | 35 (12.2%)                       | .004           |
| Outpatient procedure                          | 1523 (17.6%)               | 12 (4.2%)                        | <.001          |
| Transfusion RBC, mL/kg                        | 0.68 (5.54)                | 3.63 (12.42)                     | <.001          |
| Estimated blood loss, mL/kg                   | 0.92 (5.42)                | 2.15 (10.15)                     | <.001          |
| Total intraoperative duration MAP <2 SD, min  | 2.32 (10.9)                | 5.43 (19.2)                      | <.001          |
| Total intraoperative duration MAP 1–2 SD, min | 14.00 (27.7)               | 18.20 (32.5)                     | .012           |
| Surgical or procedural service                |                            |                                  | <.001          |
| Cardiology                                    | 970 (11.2%)                | 41 (14.2%)                       |                |
| Gastroenterology                              | 1304 (15.1%)               | 42 (14.6%)                       |                |
| General surgery                               | 890 (10.3%)                | 27 (9.4%)                        |                |
| Liver transplant                              | 123 (1.4%)                 | 26 (9%)                          |                |
| Neurosurgery                                  | 411 (4.8%)                 | 8 (2.8%)                         |                |
| Orthopedics                                   | 421 (4.9%)                 | 2 (0.7%)                         |                |
| Otolaryngology                                | 558 (6.5%)                 | 8 (2.8%)                         |                |
| Pediatric surgery                             | 874 (10.1%)                | 40 (13.9%)                       |                |
| Pediatrics                                    | 1403 (16.2%)               | 47 (16.3%)                       |                |
| Radiology                                     | 509 (5.9%)                 | 22 (7.6%)                        |                |
| Urology                                       | 489 (5.7%)                 | 21 (7.3%)                        |                |

|  | <b>No AKI<br/>N = 8636</b> | <b>Any Stage AKI<br/>N = 288</b> | <b>P Value</b> |
|--|----------------------------|----------------------------------|----------------|
| <b>Hospitalization characteristics</b> |                            |                                  |                |
| Length of stay, d                      | 0 (0–3)                    | 9 (2–19)                         | n/a            |
| ICU length of stay, h                  | 0 (0–0)                    | 0 (0–174.5)                      | n/a            |
| Ventilator time, h                     | 0 (0–0)                    | 0 (0–4.09)                       | n/a            |
| Floor-to-ICU transfer                  | 278 (3.2%)                 | 41 (12.9%)                       | n/a            |
| Outpatient ICU admission               | 12 (0.1%)                  | 4 (1.4%)                         | n/a            |
| <b>Outcomes</b>                        |                            |                                  |                |
| Mortality, in-hospital                 | 57 (0.7%)                  | 23 (8.0%)                        | <.001          |
| Readmission, 30 d                      | 584 (6.8%)                 | 60 (20.8%)                       | <.001          |

**Table 3. Propensity-Matched Adjusted Outcomes**

| <b>Propensity-Matched Cohorts</b> | <b>AKI<br/>n = 284</b> | <b>No AKI<br/>n = 852</b> | <b>Hazard Ratio<br/>(95% CI)</b> | <b>P Value</b> |
|-----------------------------------|------------------------|---------------------------|----------------------------------|----------------|
| Mortality, in-hospital            | 23 (8.1%)              | 22 (2.6%)                 | 3.28<br>(1.71–6.32)              | <.001          |
| Readmission, 30 d                 | 60 (21.1%)             | 93 (10.9%)                | 1.55<br>(1.08–2.23)              | .018           |

## Let's start by implementing measures aiming at quality improvement

- Implementation of Good or Evidence Based best practice
- Development of **evidence-based protocols** for management of serious critical events
- Development of **specific training** in the management of severe perioperative critical events
- Development and rational use of **paediatric perioperative risk assessment scores**
- Implementation of **systems for ensuring maintenance of skills**
- **Reporting patient-centered outcomes**

# SAFETOTS.ORG

- 1 NO FEAR
- 2 NORMOVOLEMIA
- 3 NORMOTENSION
- 4 NORMAL HEART RATE
- 5 NORMOOXEMIA
- 6 NORMOCARBIA
- 7 NORMONATREMIA
- 8 NORMOGLYCEMIA
- 9 NORMOTHERMIA
- 10 NO PAIN



## The 10 N