Surfactant in pediatric respiratory failure: experience and future perspectives

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Surfactant

 Ø Use in premature babies suffering from RDS
  – Improvement in survival rates
  – Possibility to treat extreme premature

Surfactant

Bolus administration (same method and dose as used in the premature baby)

- Meconium aspiration syndrome
- Bronchiolitis
- ARDS
Surfactant

Meconium aspiration syndrome

- Bolus administration: contrasting results

Surfactant

Meconium aspiration syndrome

- BAL: positive result in animals and humans
  
  - Paranka MS et al. Surfactant lavage in a piglet model for MAS. Pediatrics 1996; 97:48
Surfactant

Bolus administration

- Meconium aspiration syndrome
- Bronchiolitis
- ARDS
**Surfactant**

**Bronchiolitis**

- Therapeutic efficacy from bolus administration (50 mg/kg Curosurf single dose)
- Lung recruitment before treatment and open lung approach after surfactant

- Positive effect after 3 hours

Bronchiolitis

PaO$_2$/FiO$_2$

- mm Hg (mean)
- Time (hours)

Surf
Control

Bronchiolitis

Duration of intubation and length of PICU stay

Days (mean)

CPPV

ICU

Surf
Control

Surfactant

Bronchiolitis

- Therapeutic efficacy from bolus administration (100mg/kg one or more doses)
- Not recruitment maneuvers before surf

- Positive effects appeared starting from 24 hours

Use of surfactant

Lesson deriving from MAS
- Need for removal of inhibiting intrapulmonary material (meconium and proteins)

Lesson deriving from bronchiolitis
- Need for lung recruitment and to keep the lung open
Surfactant

Bolus administration (50-800 mg/kg dose)

- Meconium aspiration syndrome
- Bronchiolitis
- ARDS
Surfactant in adults

Acute respiratory failure and ARDS

- Surfactant improves gas exchange but does not impact on survival

- Gregory TJ et al. AJRCCM 1997; 155:1309
Surfactant in pediatric age

ARDS from sepsis (pneumonia) and interstitial pneumonia

- Surfactant improved oxygenation in all patients but decreased mortality only in direct lung pathology

✓ Marraro GA et al. Minerva Anesthesiol 1999; 65 (S1):92
Surfactant in pediatric age

ALI in infants, children, and adolescents

- Surfactant acutely improved oxygenation and significantly decreased mortality
- No significant decrease in duration of ventilator therapy, intensive care unit or hospital stay was observed

✓ Willson DF et al. JAMA 2005 Jan 26; 293:470
Surfactant in pediatric age

ALI in infants, children, and adolescents

- Willson’s study concerns
  - Not stratification of patients for age, not differentiation of lung pathologies

Surfactant in adults

Lesson deriving from ARDS

Need for
- Treatment of direct lung pathology
- Precocious surfactant application
- Better distribution and local administration

✓ Baudouin SV. Exogenous surfactant replacement in ARDS - One day, someday, or never? N Engl J Med 2004; 351:853
Surfactant

Fundamental questions based from existing data

- Could all lung pathology be treated with surfactant?
- Is it necessary to use the same bolus dose used in premature babies?
- Is it necessary recruit the lung and maintain it open?
- Is it possible obtain better result with precocious application?
Could all lung pathology be treated with surfactant?

Different results according to

- Direct (aspiration, pulmonary contusion, pneumonia) and indirect lung pathology
- Presence of multiorgan failure

Marraro GA et al. Minerva Anesthesiol 1999; 65:92
Fundamental questions based from existing data

Is it necessary to use the same bolus dose used in premature babies?

- Need for different surfactant quantity to reduce surface alveolar tension according to age

- Different origin of surfactant deficiency
  - lung immaturity in premature babies
  - surfactant inhibition and inactivation in other ages
Fundamental questions based from existing data

Is it necessary to recruit the lung and maintain it open?

- Need for homogeneity of ventilation by alveolar recruitment before, during and after surfactant

- Krause M et al. Am J Respir Crit Care Med 1997; 156:862
Fundamental questions based from existing data

Is it possible obtain better result with precocious application, avoiding compassionate use?

- Precocious treatment is beneficial for survival and outcome
New modalities of surfactant use

When
- Precocious surfactant application

Where
- Direct lung pathology (aspiration, pulmonary contusion, pneumonia)

How
- BAL with surfactant diluted in saline
- Lung recruitment before treatment and maintenance of alveoli and bronchioli continuously open
Surfactant BAL

Advantages

- Removal of material from the lung and reduction in chemical pneumonia, infection and ARDS
- Alveolar recruitment
- Better homogeneity of surfactant distribution

- Marraro GA. J Mat Fetal Neonat Med 2004; 52:29
- Balaraman V et al. AJRCCM 1998; 158:12

Disadvantages

- Complex method and need for high skilled staff
BAL and surfactant

ARS

- Wiswell TE et al. Segmental BAL ARDS. Am J Respir Crit Care Med 1999; 160:1188
Surfactant supplementation

Lung disease with pathophysiology similar to MAS can be treated with surfactant BAL?

Rationale in aspiration and pulmonary contusion

- Direct lung pathology
- Possibility of chemical pneumonia and ARDS development
- Possibility to apply precocious treatment
- Presence of inhibiting and inactivating material that can lead to surfactant deficiency
- Better distribution of surfactant
Surf-BAL in Acute Lung Injury

- Lung contusion from chest trauma in animals

Surf-BAL in Acute Lung Injury

- Aspiration and lung contusion from chest trauma in humans

- Marraro GA et al. Appl Cardiopul Pathophysiol 2004; 13 (S):324
Characteristics

- Loss of ventilating areas
- Mechanical obstruction of airway by debris, necrotic material, etc.
- Consolidation, necrosis, abscess
- Activation of humoral mediators of inflammation (edema formation)
- Development of infection and ARDS
Aims

- Removal of inactivating material present in the lung (blood, necrotic material, markers of acute lung injury, etc.)
- Lung recruitment
- Avoid consolidation of damaged areas
- Avoid secondary injury in the contralateral lung
Pathophysiology of aspiration

Characteristics

- Chemical injury to respiratory epithelium
- Activation of humoral inflammatory mediators (formation of edema)
- Development of chemical pneumonia and ARDS
Surf-BAL in aspiration

Aim of BAL

- Removal of material and inactivating substances from lung
- Prevention of chemical pneumonia and ARDS
- Avoid pathology migration by contiguity of the material
- Lung recruitment
- Stabilization of small airways and alveoli
Surf-BAL in pulmonary contusion and in aspiration

Beneficial effects

- Reduction of intubation and mechanical ventilation duration
- Improvement in gas exchange and pulmonary function
- No complications during and after surfactant-BAL
New perspectives in surfactant supplementation in ALI and ARDS

Need for

- Treatment of direct lung pathology (aspiration, pulmonary contusion, pneumonia)
- Application of protective lung strategy and open and keep the lung open
- Precocious treatment avoiding compassionate use
- Administration of surfactant using a different strategy than bolus
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Thank you for your attention

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