Non invasive ventilation in unusual situations

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Introduction

- Equipment
- Effects of NIV
- Complications
- Patient selection
- Practical aspects

Noninvasive ventilation

- Delivery of positive pressure ventilation through an interface to upper airways of the patient without the use of invasive airway
- NIV is able to improve gas exchange and unload respiratory muscles as efficiently as invasive ventilation

Wysocki M et al, Eur respir J 2001

Advantages:NIV

- Achieves alveolar ventilation and gas exchange parameters similar to IMV
- Avoids invasive airway
- Avoids sedation /paralysis

Reduced Infections (VAP, sinusitis) ICU Stay & mortality

- Can be applied intermittently as required
- Permits removal of secretions, eating and speech
- Patient participates in decision making

Antonelli M et al, Crit Care 2000

Nasal Vs oronasal mask

Variables	Nasal	Oronasal
Comfort	+++	++
Claustrophobia	+	++
Rebreathing	+	++
Lowers CO_2	+	++
Permits expectoration†	++	+
Permits speech‡	++	+
Permits eating§	+	−
Functions if nose obstructed	−	+

Liesching T et al , Chest 2003

Portable vs critical care ventilators

	Ventilators	
Variables	Critical Care	Bilevel†
Inspiratory pressure	++	++
Leak tolerant	+	++
Different modes	++	+
Alarms	++	+
Monitoring capability	++	+
Battery	+	−
Oxygen blender	++	−
Compactness	+	++

Liesching T et al , Chest 2003

Modes of NIV

- Continuous positive airway pressure
- Pressure support ventilation(IPAP alone)
- Bilevel positive airway pressure: BiPAP (IPAP+ EPAP)
- Proportional assist ventilation
- Assist-controlled ventilation (mask IPPV)

Craig TH, Emerg Med 2002
Mehta Set al, AJRCCM 2001

Effects : IPAP

- Reduces the work of breathing
  - Alleviates respiratory distress
  - Unloads respiratory muscles
  - Improves respiratory muscle function
- Auguments alveolar ventilation: reduces dead space ventilation
- Reduces rate related auto PEEP dynamic hyperinflation
- Improves gas exchange: hypoxemia and hypercapnia

Antonelli M et al, Crit Care 2000

Effects : EPAP

- Improves gas exchange: by alveolar recruitment and corrects hypoxemia
- Increases FRC by preventing end exp collapse: improves lung compliance into advantageous position, higher tidal volumes generated for same pressure change
- Improves respiratory muscle fn : reduces dynamic hyperinflation advantage to the diaphragm and intercostals
- Auto PEEP (Inspiratory threshold load) : reduces effort trigger ventilator by equalization of pressures
- Enhances the delivery of bronchodilators to distal bronchial tree

Antonelli M et al, Crit Care 2000

Triggering

- Most portable ventilators have flow triggering
- Pressure triggering : associated with increased work of triggering with auto PEEP (in AE of COPD)
- Auto PEEP significantly lower with flow triggering in PSV mode

Fractional inspired Oxygen

- FiO_2 variable: pulse oximetry and serial ABG are a must
  - IPAP & EPAP settings (High-causes fall in O_2)
  - Oxygen flow rate
  - Site of oxygen source (mask hole/ventilator/ circuit)
  - Site of leak port
  - Air leak

Hess DR, Respir Care 2004

Humidifier

- Controversy related to use of humidifier as upper airways are not bypassed
- NIV is required for longer periods >48-72h recommended to use(prevent inspissated secretions due to high flow rates)
- Mouth leak : nasal resistance can be minimized by humidifying air
- HME are not recommended as they increase the work of breathing

Hess DR, Respir Care 2004

Who should receive NIV

Appropriate diagnosis with potential reversibility
→ Establish need for ventilatory assistance
- Moderate to severe respiratory distress
- Tachypnea
- Accessory muscle use or abdominal paradox
- Blood gas derangement
  - pH < 7.35, $PaCO_2 > 45$ mm Hg, or
  - $PaO_2/FIO_2 < 200$

→ Exclude patients with contraindications to NPPV
- Respiratory arrest
- Medically unstable
- Unable to protect airway
- Excessive secretions
- Uncooperative or agitated
- Unable to fit mask
- Recent upper airway or gastrointestinal surgery

Liesching T et al , Chest 2003

Predictors of success : ARF

- Younger age
- Lower severity of illness (APACHE score)
- Better neurologic score (more cooperation)
- Ability to coordinate with ventilator
- Less air leak(intact dentition)
- Hypercapnia(CO_2>45 , <92 mmHg)
- Acidemia (pH <7.35, >7.10)
- Improvement in gas exchange ,HR and RR witihin first 2 hours

Mehta S et al, AJRCCM 2001

Predictors :Poor outcome

- High APACHE score
- Low level of conciousness
- Low pH
- More secretions
- More air leak
- Poor initial response to NIV(1hour)
- Presence of Pneumonia/ARDS
- Older age

Hess DR, Respir Care 2004

NIV failure

- NIV is least likely to succeed in the patients who are most sick and late in course of disease
- Must not deter the clinician from trial of NIV wherever eligible
- Have low threshold for intubation in sicker patients ,more likely to have NIV failure

Hess DR, Respir Care 2004

NIV: Complications

- Major complications have been reported relatively infrequently (~1-2%)
- The caveat is that patients must be carefully selected for NIV
  - Early application
  - Monitoring continuous oximetry/ABG & ECG
  - Periodic observation: signs of deterioration
  - Facility for timely intubation and MV available

Complications: interface

- Nasal – congestion /dryness /rhinorrhea
- Nose bridge- erythema /ulceration
- Conjunctival irritation
- Sinus pain /earache
- Nasal /oral dryness
- Claustrophobia

Air leak

- Universal to have some airleak
- Monitored - determinant of success of NIV
- Nasal mask : mouth leak may increase nasal resistance due to unidirectional flow
- Minimized by mouth closure or use chin straps
- Oro-nasal masks: in ARF as mouth breathing common in resp distress

Effects : air leak

- Significant air leak for most bilevel devices is 0.4L/sec above intentional leak
  - Decreased effectiveness ventilation (NIPSV)
  - Inability to maintain optimal pressures (CPAP)
  - Sleep fragmentation
  - Inability to trigger ventilator
  - Prolonged inspiratory time
  - Greater oxygen requirement

Rabec CA et al, Arch Bronconeumol 2004

Patient ventilator asynchrony

- Air leaks affect triggering & cycling: ventilator fails to sense inspiratory effort or onset of expiration
- Prolonged inspiratory time for ventilators patient has to imposed work during expiration
- Respiratory distress “worsens” with NIV than improves think of asynchrony
  - *Mehta S,Hill NS AJRCCM 2001*

Rebreathing

- Reduce the ability of NIV to lower CO_2
- Problem with portable devices (single tubing, mask dead space, and tachypnea)
- Minimized by the presence of expiratory ports on the mask (best –ports opposite air inlet)
- Should not be significant when expiratory pressures of ~ 4 cm H_2O are used to provide adequate bias flow.

Antonelli M et al, Crit Care 2000

Haemodynamic effects

- Noninvasive ventilation is usually well tolerated due to lower pressures as compared to IMV
- Underlying cardiac disease
- Borderline haemodynamic status

extreme caution required : start at lower inflation pressures (10/4 cmH2O) with close monitoring for adverse effects

- Gabrielli A et al, Chest 2003

Rare complications

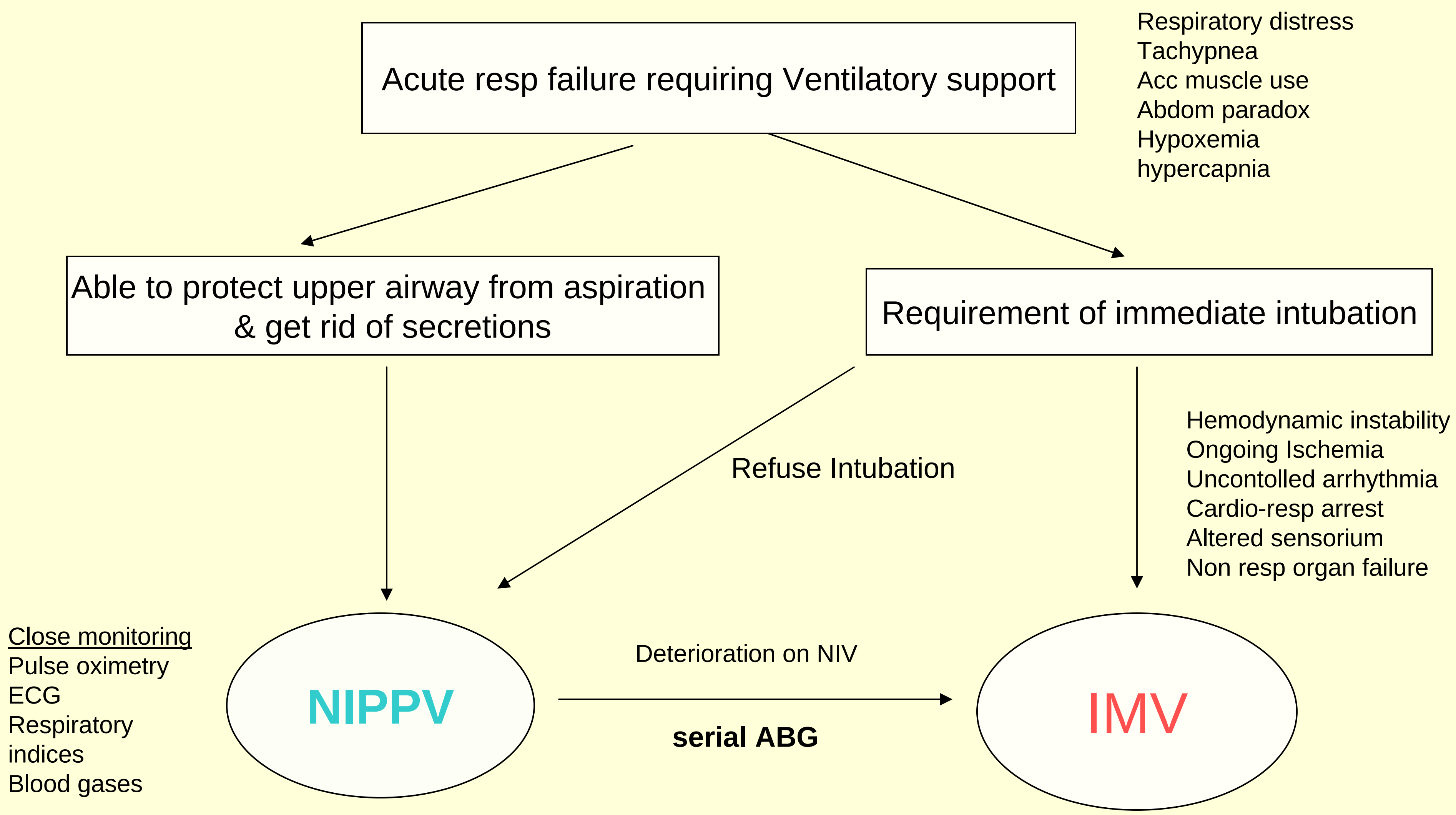
- Gastric distension (UES opens 20-25cm H_2O may require NG tube for distension)
- Aerophagia
- Aspiration
- Nosocomial pneumonia
- Pneumothorax

Mehta S Hill NS,AJRCCM 2001

Rarer complications

- Pneumomediastinum
- Air embolism – stroke
  - *Hung SC et al Eur Respir J 1998*
- Esophageal perforation
- Esophago-pleural fistula
  - *Hurst JR et al , Thorax 2003*
- Upper airway obstruction due to Inspissated oro-pharyngeal secretions
  - *Hill NS, Resp Care 2000*

Practical approach



Indications of NIV

- Indications of NIV are ever expanding and there remain no boundaries or absolute contraindications to its application
- Gold standard for ventilatory support remains intubation and conventional ventilation (IMV)
- NIV should be viewed as a complementary strategy to avoid ETI and its complications and not as an alternative to IMV

Brochard L Eur Respir J 2002

Acute resp failure :NIV

Strong (multiple controlled trials)	COPD exacerbations Acute cardiogenic pulmonary edema* Immunocompromised patients Facilitation of weaning in COPD patients
Less strong (single controlled trial or multiple case series)	Asthma Cystic fibrosis Postoperative respiratory failure Avoidance of extubation failure DNI patients
Weak (few case series or case reports)	Upper airway obstruction Acute respiratory distress syndrome (ARDS) Trauma Obstructive sleep apnea, obesity hypoventilation

Liesching T et al , Chest 2003

Special situations

- Acute severe asthma
- Diastolic heart failure
- Acute lung injury/ARDS
- Neuromuscular ARF
- Flail Chest
- Bilateral diaphragmatic palsy
- Upper airway obstruction
- Fibreoptic bronchoscopy

Acute severe Asthma

Ac Severe Asthma

- Significant increase expiratory resistance: airflow limitation and tachypnea
- Dynamic hyperinflation (auto PEEP)
- Mucus plugging and collapse : V/Q abnormalities
- Respiratory muscle fatigue : dead space ventilation, hypercapnia and resp acidosis

  (seen if $FEV_1 < 25$ % predicted)

NIV in ASA

- IPAP
  - Reduces WOB and distress
  - Reduces respiratory rate
  - Auguments tidal volume
- EPAP
  - offsets auto PEEP reduces the imposed inspiratory threshold load
  - Improves the adverse haemodynamics
- Resp muscle function improves - reduced dynamic hyperinflation, better O_2 and rest
- Improved delivery of bronchodialators

Bronchodilator delivery

- Bronchodilator delivery with IMV significantly reduced by deposition on tubings and heated humidification(~ 40%)
- SVN and MDI are equally effective with IMV : MDI is cheaper and less likely to have contamination
- BiPAP driven aerosol quicker improvement in PEFR than without (? effect of BiPAP/drug)
- Optimal position of nebulizer – between leak port and patient end of connection ,with high IPAP and low EPAP

Ceriana Pet al , Monaldi Arch Chest Dis 2003

NIV:ASA

- 17 episodes of ASA (over 3 years)
- Face mask IPAP 14 ± 5cm EPAP 4 ± 2 cm used (with medical treatment)
- NIV improved : pH,PaCO2,PaO2/fiO2 in 15/17
- Two required intubation due to worsening hypercapnia
- Duration of NIV was 16± 21h
- Length of hosp stay was 5 ±4 days

Meduri GU et al ,Chest 1996

Conclusion

- NIV using face mask was highly effective in correcting gas exchange abnormalities at lower inspiratory pressures (< 25 cm H2O) and preventing tracheal intubation.
- Recommend randomized study to evaluate the role in status asthmaticus

Meduri GU et al ,Chest 1996

RCT NIV:ASA

- Randomised to NPPV=15 and usual medical care group UMC=15
- FEV1 < 60% pred, RR> 30/min, h/o asthma⩾ 1yr & current asthma attack>7d
- Nasal mask , BiPAP used
- Intermittent for 3h with break for 5 mins expectoration /nebuliztion /spirometry
- Compared with UMC + “sham” NIV

Soroskys et al , Chest 2003

NIV:ASA

- ABG/Spirometry/Biochem/CXR
- No deaths or tracheal intubation in NIV group
- Hospitalization rate was lower with NPPV (RR 0.28 (95% CI 0.09 to 0.84)
- Patients discharged from ER after treatment higher in the NIV (RR 2.26 (95% CI 1.03 to 4.97)
- Signific improved RR & spirometry values at 3 h
- Treatment failure, LOS ICU, and HR were not significantly different.

Soroskys et al , Chest 2003

Conclusion

- NPPV using low inspiratory pressures (< 15 cm H2O) was highly effective in rapidly improving lung function, respiratory rate, and decreasing hospitalization in acute severe asthma
- Larger randomised controlled trials recommended
- NIV restricted to carefully selected cases with optimal medical management
- Routine clinical use in Ac severe asthma not recommended.

Sorokskys et al , Chest 2003

Cochrane review

- Role of NIPPV in patients suffering from status asthmaticus, encouraging preliminary results but still remains controversial.
- Large, prospective randomised controlled trials are needed to determine the role of NIPPV in SA

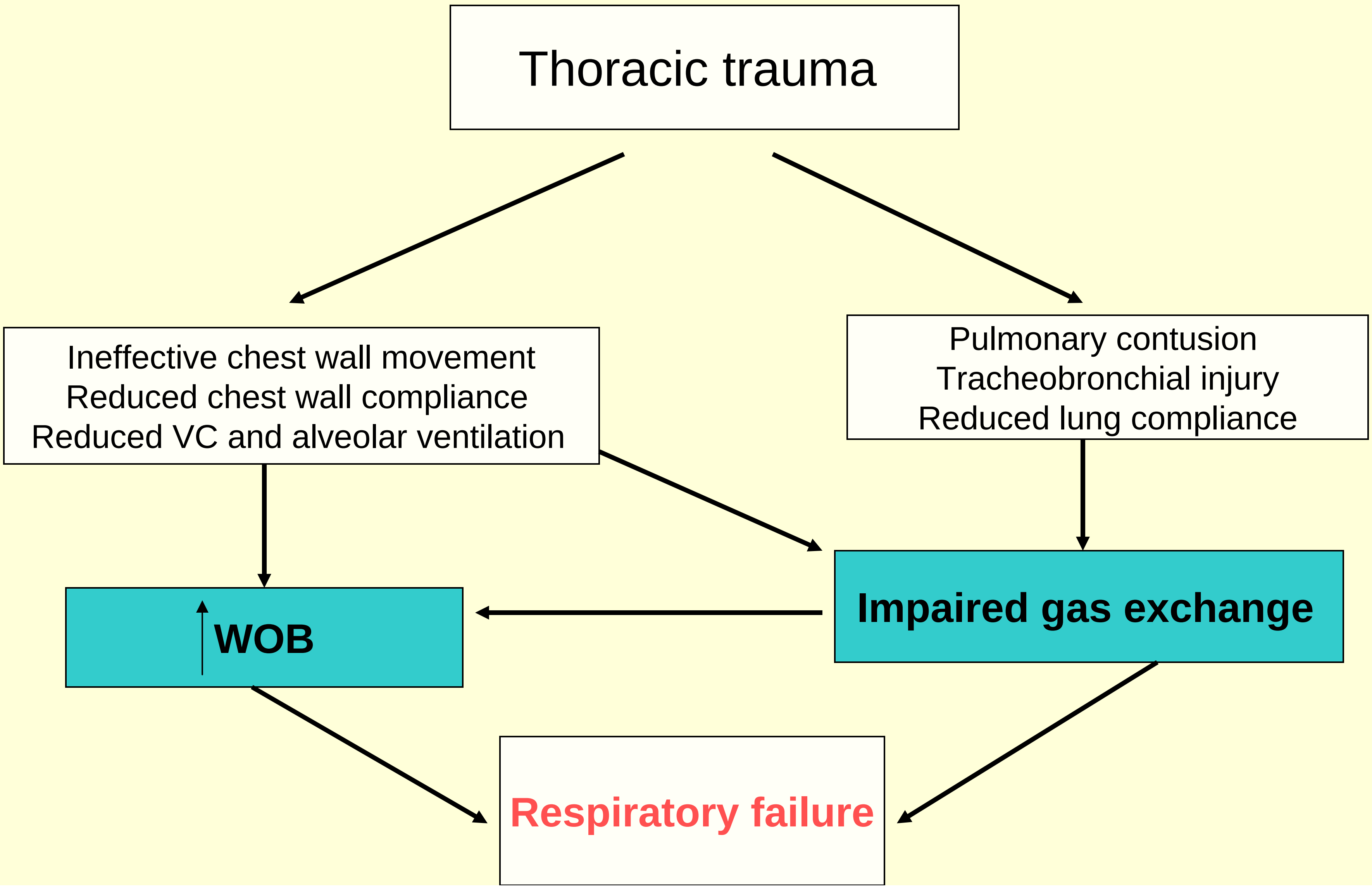
Ram FSF et al , Cochrane database of Syst reviews 2005

Thoracic trauma

Spectrum of severity

- Rib fracture
- Flail Chest
- Tracheo-bronchial injury
- Pulmonary contusion
- Pulmonary edema
- ARDS
- Pneumothorax / hemothorax

Flail Chest - ARF



NIV: Flail chest

- Prolonged invasive ventilation required with flail chest which increases risk for VAP and prolongs ICU stay
- NIV in flail chest
  - Avoids tracheal intubation
  - Reduces nosocomial infections
  - Reduces morbidity & mortality
  - Reduces ICU stay
  - Reduces hospital stay and costs

Garfield MJ et al Br J Anaesthesia 2000

Pathological flail chest : NIV

- Elderly female with multiple myeloma and pathological flail chest (rare)
- Pneumatic stabilization by IMV used to allow healing
- Surgical stabilization used for severe flail chest, associated with more complications
- BiPAP support through tracheostomy and definitive chemotherapy(~3months)

J. Abisheganaden et al , Eur Respir J 1996

Flail chest : RCT CPAP vs IMV

Parameters	CPAP n= 25	ET n= 27
Nosoc infection	4/22	10/21 ($p = 0.001$).
Hosp survival	14/21	20/22 ($p<0.01$)

- CPAP led to lower mortality and lower nosocomial infection rate compared to IMV (with similar oxygenation and LOS-ICU)
- Recommended as first line treatment for flail chest

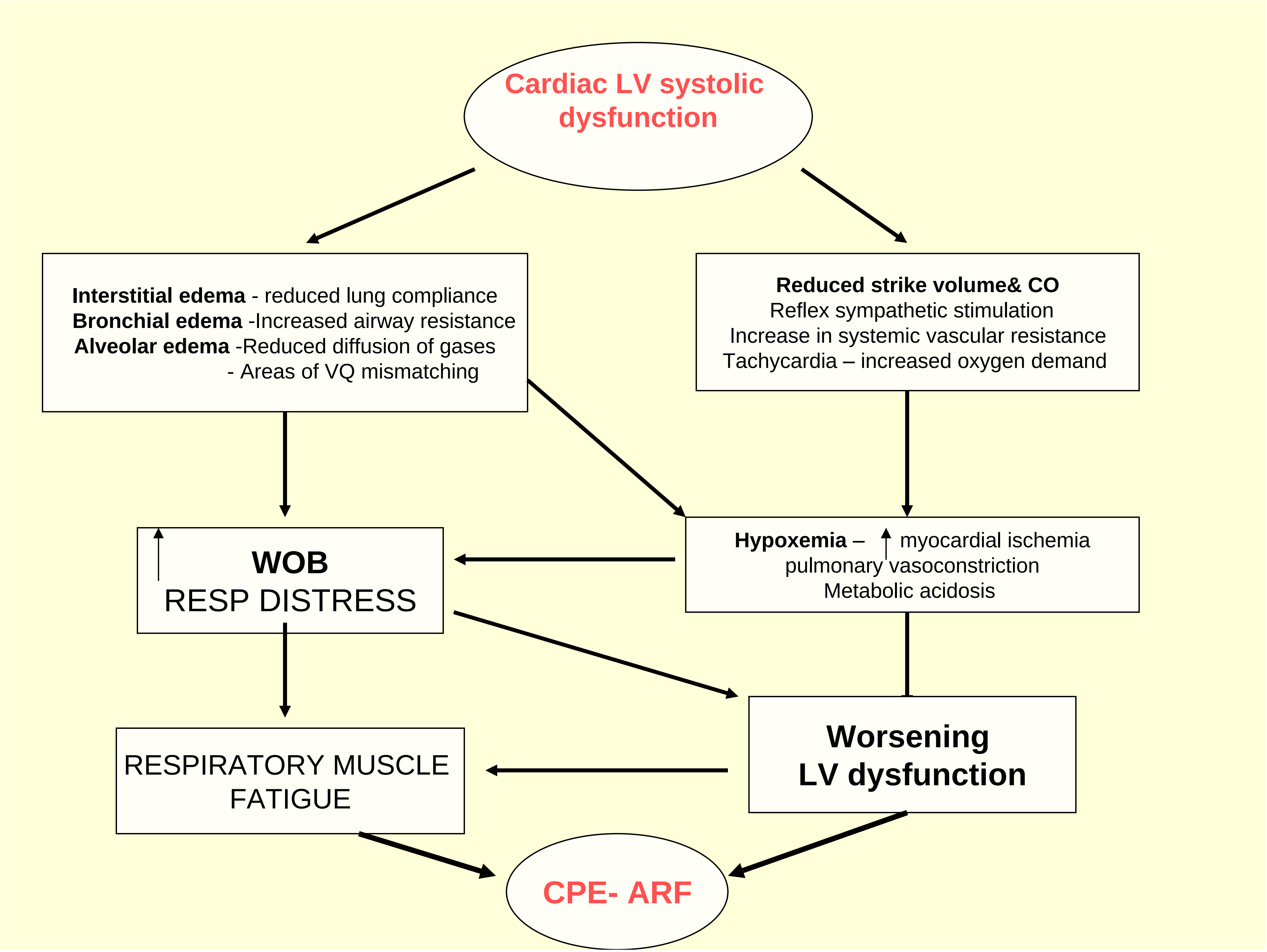
Gunduz M et al, Emerg Med J 2005

CPE - DHF

Cardiogenic pulmonary edema

- CPE represents the 2nd common cause for NIV application in acute setting after ARF due to acute exacerbation of COPD.
- CPAP: been used for many decades with proven benefit in reducing ETI,ICU stay and mortality
- BiPAP: combines the effects of EPAP and pressure support rapid relief of distress and gas exchange in CPE
- BiPAP has been associated with increased incidence of AMI and mortality in few studies

Leisching Tet al, Chest 2003


Cardiac LV systolic dysfunction
Interstitial edema - reduced lung compliance
Bronchial edema -Increased airway resistance
Alveolar edema -Reduced diffusion of gases
- Areas of VQ mismatching
Reduced strike volume& CO
Reflex sympathetic stimulation
Increase in systemic vascular resistance
Tachycardia – increased oxygen demand
↑ WOB
RESP DISTRESS
Hypoxemia – ↑ myocardial ischemia
pulmonary vasoconstriction
Metabolic acidosis
RESPIRATORY MUSCLE FATIGUE
Worsening LV dysfunction
CPE- ARF

CPE : metaanalysis

- Improves haemodynamics and respiratory parameters along with conventional treatment
- CPAP decreases intubation rate and improves survival (NNT 7 and 8)
- Decreased use IMV ,shorter ICU stay & hosp stay and reduced mortality in selected cases
- Insufficient evidence for use of Bilevel positive airway pressure (BiPAP) except hypercapnic CPE
- BiPAP needs further evaluation in CPE

Agarwal R et al , Postgrad Med J 2005

Vicious cycle: CPE

- Resp distress causes large negative intrapleural pressure swings which
  - Increases venous return: Preload
  - Increases transmural LV pressure : afterload
  - LV function deteriorates further compounds the hypoxemia- ischemia-dysfunction cascade

  " Dyspnea and resp distress is not due to hypoxemia,not reversed by oxygen therapy"

Agarwal R et al , Postgrad Med J 2005

CPAP in CPE

- Reduces WOB (unloads muscles ,reduces distress): augments inspiratory and expiratory flow and pressure
- Re-expands flooded alveoli: prevents micro-atelectasis , improves lung compliance
- Improves hypoxemia : increased alveolar ventilation & better gas exchange
- Counteracts AutoPEEP
- Improves thoracic pump: $\downarrow$ Auto PEEP, $\uparrow$ compliance , muscle rest , better oxygenation

Agarwal R et al , Postgrad Med J 2005

CPAP in CPE

- Effective function filling and emptying depends on difference in thoracic pressure and LV pressures (cardiac transmural pressure)
- During diastole positive intrathoracic pressure reduces venous return : reduces RV,LV preload
- During systole reduces the afterload : improves the cardiac index of failing heart
- Causes significant decrease in the heart rate due to parasympathetic tone (by CPAP induced lung inflation)

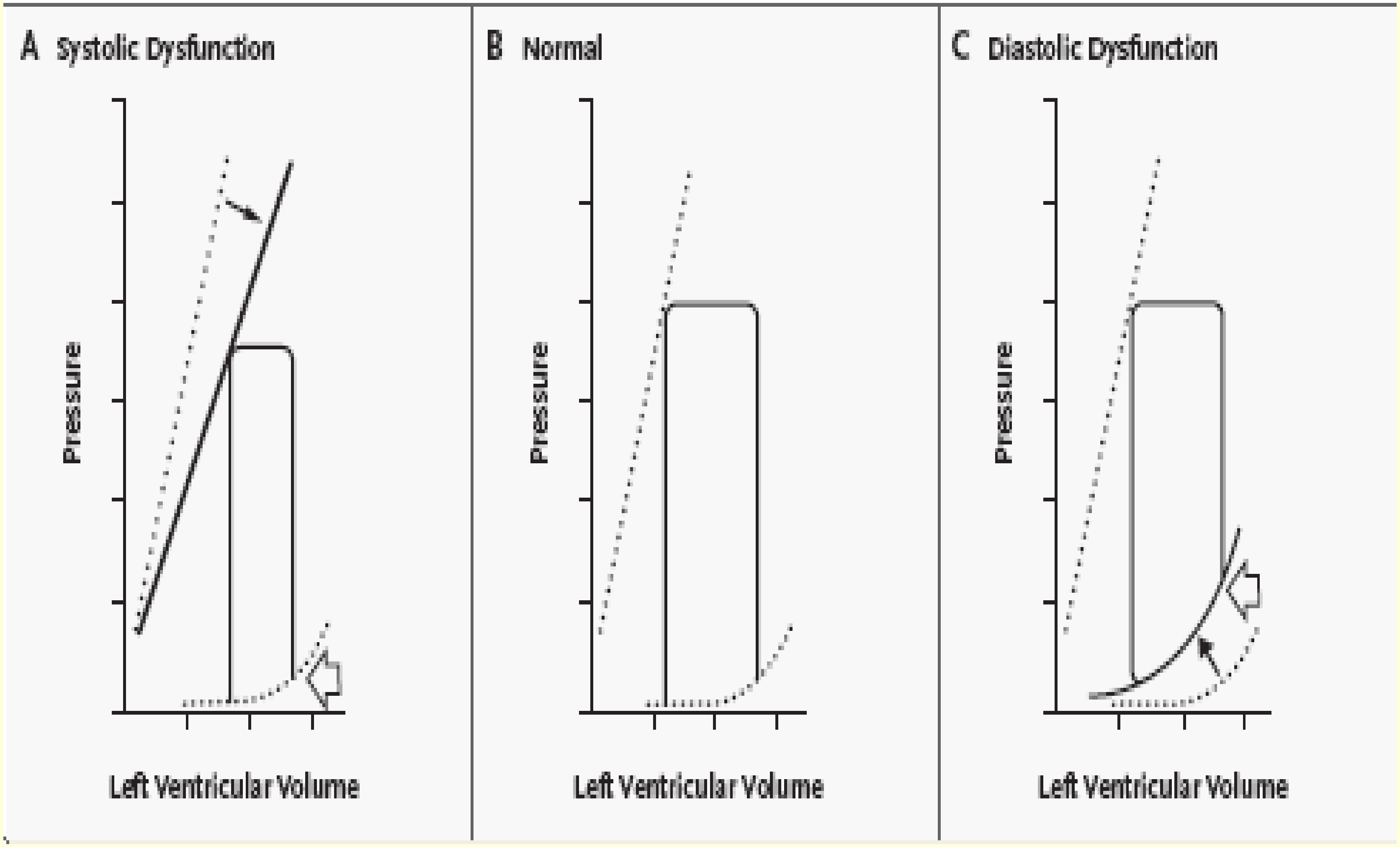
Agarwal R et al , Postgrad Med J 2005

Diastolic heart failure

- Disease associated with abnormal LV filling or relaxation with normal LV size and systolic function (i.e. LVEF>40-50%)
- Inability of the LV to fill at normal LA pressures
- Diastolic functions depends on
  - Active (diastolic) relaxation of LV
  - Passive elastic properties of LV
    - Increases myocardial mass (LVH)
    - Altered extramyocardial collagen network

Aurigemma GA, N Engl J Med 2004

LV pressure volume loops



Aurigemma GA N Engl J Med 2004

Pathophysiology

STIFF LV

↓

Reduced LV compliance

↓

Elevated LVEDP
shift of LV pressure volume curve (U & L)

↓

LA+ PV Pressure increases(↑ blood volume or venous tone or systemic arterial resistance)

↓

Pulmonary edema

CPAP in DHF

- Effects of CPAP on cardiac function in DHF (first study using Echocardiography)
- LV diastolic dysØ was defined as LVEF>45% , aortic velocity integral >17cm
- Nine cases of CPE: CPAP 10 cm H2O by mask with FiO_2 to keep SpO_2 >90%
- Doppler Echo: before and during last 10 min of CPAP.
- Oxygenation and ventilatory parameters improved by CPAP in all cases

Bendjelid K et al, Chest 2005

CPAP in DHF

- LV Diastolic dysØ (n=4) : MAP and LV ED volume were decreased significantly
- LV systolic dysØ (n=5): improved LVEF ($p < 0.05$) decreased LV ED volume ($p=0.001$) significantly
- Conclusion: in patients with preserved LV systolic function, hemodynamic benefits of CPAP results from a decrease in LV end-diastolic and volume (preload).

Bendjelid K et al, Chest 2005,

CPAP in DHF

- Inadequate LVEDV is the basic patho-physiogic abnormality in DHF
- Further lowering of preload (CPAP) will cause fall in SV and CO in DHF
- May lead to hypotension,and prerenal azotemia
- Improvement of CPE : due to ↓ HR with CPAP reduced oxygen demand and improved diastolic filling of LV
- BiPAP maybe superior with DHF (as varying pressures during I and E)
- Role of CPAP in DHF requires larger studies and till then caution during use of CPAP in DHF

Agarwal R et al Chest 2005 (in press)
Gabrielli A et al Chest 2003

ALI/ARDS

ARDS

- Alveolar edema
- Atelectasis

V/Q mismatch
Intrapulmonary Shunt

- Pulmonary vasoconstriction and micro-thrombi formation(dead space ventilation)
- Reduced lung compliance
- Increased work of breathing
- Respiratory muscle fatigue

IPAP

- Reduces the work of breathing
- Reduces dyspnea
- Resp muscle function improves
- Improves alveolar ventilation
- Improves gas exchange

Antonelli M Eur Respir Monograph 2002

EPAP

- Acts like PEEP in ALI /ARDS
- Alveolar recruitment : keeping the alveoli open at end of expiration, improves FRC and lung compliance
- Preventing alveolar derecruitment : reducing shear stress of alveoli (atelectotrauma)
- Improves gas exchange - increase of Mean airway pressure: alleviates hypoxemia

Antonelli M Eur Respir Monograph 2002

ARDS

- Studies on use of NIV in ARDS are few and the outcome is conflicting
- None have studied the role of NIV on mortality in ARDS
- Recent systematic review concluded addition of NIV to standard care in AHRF reduced the rate of ETI, ICU stay and mortality (but majority of cases were Pneumonia not ARDS)

Keenan S et al, Crit Care Med 2004

Meta-analysis

- Four RCT, including 184 patients of ARDS
- NIV was more effective than standard therapy in preventing ETI (RR -0.24, 95%CI, -0.44 to -0.05)
- There was no survival benefit (RR -0.06, 95%CI, -0.19 to -0.06)
- Limitations : post hoc design ,different modes of NIV, significant heterogeneity, diverse case mix
- Large Randomized controlled trials are required to determine the role of NIV in ARDS

Agarwal R et al (Unpublished data)

Conclusion

- NIV should be tried in “early” ARDS that is not responding to standard therapy, “window of opportunity is small ”
- Should not be used if refractory life threatening hypoxemia (PaO_2/FiO_2<60)
- Close observation for detecting NIV failure and facilities for intubation should be available when being applied

Neuromuscular resp failure

Neuromuscular Resp failure

- NIV is well established in chronic resp failure due to neuromuscular causes
  - Duchenne muscular dystrophy
  - Post-polio paralysis
  - MND
- Acute respiratory failure : short case series or anecdotal case reports
  - Gullain Barre syndrome
  - Neurotoxic snake envenomation
  - Myaesthenic crisis

Acute NM resp failure: NIV

- Effective specific therapy: myasthenia gravis and GB syndrome
- Rapidity of reversal of basic disease: neurotoxic snake envenomation
- Type of ventilatory support
  - severity of the ventilatory failure
  - presence of bulbar involvement
  - other contraindications for NIV
- Facilities for close monitoring & intubation

Myasthenic crisis: BiPAP

- Eleven episodes in nine patients were initially managed with BiPAP
- ETI was avoided in seven episodes
- Presence of hypercapnia ($PaCO_2$ > 50 mm Hg) at onset predicted BiPAP failure
- NIV may prevent intubation in patients with myasthenic crisis without hypercapnia.

Rabinstein A , Neurology 2002

Myasthenic crisis: NIV

- NIV was used successfully for myasthenic crisis
- Myasthenia gravis after thymectomy on steroids and cholinergic drugs.
- Patient had worsening limb weakness, bulbar involvement (not able to swallow or cough)
- BiPAP with nasogastric tube and intermittent oral suctioning
- IVIg was given for rapid improvement, steroids continued
- Patient improved after 3 days and was discharged

Ararwal R et al, Emer Med J 2005 (in press)

LGB syndrome

- Respiratory failure due to LGB syndrome
- absence of weakness of the bulbar muscles allowed the safe use of non-invasive ventilation for 2 weeks
- Invasive ventilation and tracheostomy were avoided
  - *Pearse RM et al Br J Anaesth 2003*

Neurotoxic snake envenomation

- Rapidly reversible disorder common in tropics
- Use of NIV for NMRF due to NTS has been reported from our Institute
- Patient had respiratory distress with abdominal paradox, mild hypoxemia without hypercapnia and was able to cough and swallow saliva
- SAV was given (150ml) & NIV support for 8 hours with successful avoidance of ETI and associated complications

Agarwal R et al, Anaesthesia 2005 (in press)

Bilateral Diaphragmatic palsy

- 68 Y lady had ARF ,was put on IMV ,no lung disease or neuromuscular disorder was detected
- Suspected of having a phrenic-diaphragmatic impairment after 3 weeks of MV
- Confirmed to have BDP on fluoroscopy, phrenic nerve stimulation and EMG
- Patient was successfully weaned from the IMV by nasal mask BiPAP ventilation
- Was on domiciliary BiPAP at f/u 6months

M.C. Lin ,Eur Respir J 1997

Upper air way obstruction

UAO:NIV

- Clinical data in UAO are limited to short case series
- Fixed upper airway obstruction is a contraindication for NIV, and should be treated with IMV ,however NIV may be used if it is the ceiling treatment modality

BTS guidelines ,Throax 2002

Malignant airway obstruction

- acute respiratory failure secondary to variable intrathoracic large airway obstruction due to a lung neoplasm
- Successful ventilation was achieved with facemask bilevel non-invasive ventilatory assistance allowing radiotherapy and chemotherapy to be undertaken.

Grant RK et al , Anaesth Intensive Care. 1999

UAO infants: NIV

- Infants with severe UAO, compared CPAP to BIPAP ventilation
- laryngomalacia (n=5), tracheomalacia (n=3), tracheal hypoplasia (n=1), and Pierre Robin syndrome (n=1)
- Significant decrease in respiratory effort with both modes (RR, breath pattern,esophageal Trans diaphragmatic pressures)
- BIPAP ventilation was associated with patient-ventilator asynchrony

Essouri S et al,Inten care Med 2005

Fibreoptic bronchoscopy

CPAP in FOB

- FOB may worsen oxygenation in severely hypoxemic
- Prospective, randomized, double-blind trial
- Delivery of CPAP for maintaining oxygenation compared with delivery of oxygen during FOB
- SpO2 values were much higher in CPAP gp (95+1.9 vs 92+3.1%)
- PaO2 increased in CPAP and fell in Oxygen gp
- 5 patients Oxygen gp developed resp failure within 6 hours of FOB and required MV
- **CPAP device during FOB: minimal alterations in gas exchange and prevented subsequent respiratory failure**

Bernard M et al, AJRCCM 2000

NIV + Helmet mask :FOB

- Helmet NIV during FOB used for 4 cases with AHRF with pneumonia
- Avoided gas exchange and haemodynamic deterioration during FOB + BAL with good tolerance
- During the procedure HR increased by 5% and MAP by 7% over baseline values
- Tracheal intubation was not required during the 24 h after the procedure
- **Permits safe diagnostic FOB with BAL in patients with hypoxemic ARF, avoiding gas exchange deterioration, and endotracheal intubation**

Antonelli et al, Int Care Med 2003

Take home message

- Careful Patient selection is critical for success of NIV
- Close observation & monitoring
- Failure reduce obvious signs of WOB and to improve gas exchange in 1-2 hours should initiate IMV
- CPAP may be detrimental in DHF with CPE (use BiPAP initially)

Thank you...