RESEARCH PAPER | Medical Science | Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

Non invasive positive pressure ventilation strategy in acute respiratory failure - predictors outcome in intensive respiratory care unit in tertiary care center.

KEYWORDS: NIV- non invasive ventilation, NIPPV- non invasive positive pressure ventilation, BiPAP- bilevel positive airway pressure, ARF- acute respiratory failure, APACHE II – acute physiology & chronic health evaluation Pimax –maximum inspiratory pressure, PEmax – maximum expiratory pressure RR – respiratory rate ,VT –Tidal volume, RSBI –Rapid shallow breathing index AUROC- Area under the receiver operative curve.

Dr. Ramakrishna V. Ghubde
Associate professor in Respiratory & Respiratory critical care medicine.Smt.Kashibai Navale Medical College & GH.PUNE.

Dr.Archana Shekokar
Professor in anatomy. Smt.Kashibai Navale Medical College & GH.PUNE.

ABSTRACT *Aims- To identify predictors of successfully non invasive ventilatory treatment strategy in patients of acute respiratory failure of diverse etiology .*

This was a prospective observational study. All patients with acute respiratory failure receiving NIV treatment were enrolled in study IRCU of a teaching hospital at SKNMC& GH Pune.India Patients were enrolled if they had acute respiratory failure & had been admitted in intensive respiratory care unit bet 1st Jan. 2014 to 31st dec .2014.

During study period all 82 patients who satisfied the study inclusion criteria agree to participate in study & keep follow up of every patient until discontinuation of NIV Or their death .On the basis of APACHE II score prior to treatment . serial measurements of respiratory rate ,tidal volume ,rapid shallow breathing index ,maximal inspiratory pressure [PI max],Maximum expiratory pressure [PEmax] prior to & ½ an hour & 1 hour Subsequent to NIV treatment .[Subscripted Numbers 0, 30min ,60min]. NIV treatment was determined as successful in 52 patients . [success groups where patients endotracheal intubation was avoided & failure group 30 patients. APACHEII score prior to treatment Pimax 30[pimax 30 min .subsequent to NIVRR30 min subsequent to NIV ,RR60 min subsequent to NIV Were all significantly lower in success group than Failure groups. The success group also had significantly better values for RR during first 30 min of NIV treatment & PE max during first 60 min of NIV treatment ,. compared to patients with failure group.

Introduction

The mechanical ventilation is first line treatment for patients of acute respiratory failure .ARF patients can be ventilated either with positive or negative pressure, invasively or noninvasively .NIV is the provision of ventilatory support to the lungs without the use of an endotracheal way. NIV has revolutionized the management of ARF & has been applied in diverse forms of ARF. It reduces the need for endotracheal intubation & complications like airway trauma , infections, etc also reduces the complications associated stay in IRCU /Hospital , mortality in selected group patients. [1,2,3,4]

The evidence for the use of NIV remains stronger with hypercapnic ARF due to exacerbations of COPD &cardiogenic pulmonary oedema ,[4,6,17,19], Positive pressure therapy can be delivered noninvasively by non invasive positive pressure ventilation [NIPPV] or bi-level positive airway pressure &continuous positive airway pressure . In NIPPV two different pressures are used viz inspiratory positive airway pressure IPAP &Expiratory positive airway pressure EPAP. CPAP maintains a constant positive airway pressure throughout the respiratory cycle. NIPPV may confer as advantage over CPAP by reducing the work of breathing during inspiration by providing additional inspiratory pressure .

There is strong evidence to support the use of NIPPV in COPD [5]

Two recent meta analysis didn't find any strong evidence to support the role of NIV in acute hypoxic respiratory failure & acute respiratory distress syndrome.[5,6].

NIV which is the provision of mechanical respiratory assistance without endotracheal intubation in the management of acute respiratory failure, appears to increasing not only in IRCU /ICU/MICU also in emergency department & general wards. [7,8] Many well designed randomized controlled trials have demonstrated the relative efficacy NIV as regards averting the need for endotracheal intubation .[5,6]. NIV is now being considered more as respiratory support for acute respiratory failure .

For some patients, application of NIVmay lead to clinicians missing the optimal time window for endotracheal intubation & poor outcome.Therefore the accurately selection of patients a desirable goal [7,8]

The number of respiratory assist patients varies in different study .it is difficult to accurately predict NIV treatment response on the basis of relative severity of underlying lung disease, forced expiratory volume in first second of forced exhalation .Arterial blood gas analysis [Pco2,PH] obtained prior to beginning NIV.

The rapid shallow breathing index RSBI is accurate index for Predicting

Ventilator weaning success was introduced by to accurately predict the response , outcome of NIV treatment in acute respiratory failure &relative feasibility of RSBI & other respiratory indices .[7,9]

Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

We conducted a prospective observational study in intensive respiratory critical care unit of teaching hospital .

Patients & methods

We underwent study cases with acute respiratory failure, who had been admitted in our adult IRCU of the institute.who had received mechanical ventilatorary support. Subsequently, If the patients met the following criteria, Initially they were treated with NIV .

A] stable haemodynamics
B] endotracheal intubation not needed
C]upper airway obstruction – absent
D]No bulbar dysfunction
E] No cardiac arrhythmias
F] No upper & lower GIT bleeding

Initially all the patients received NIV with the use of portable non invasive ventilator VPAPII [Resmed australia]NIV was administered to patients in bed at an angle of 30-45 degree.& a full face mask was used as an interface for delivery of positive pressure . At the outset the patient was started on IPAP of 8 & EPAP of 4 cm H2o. The pressure were gradually adjusted .based on pulse oximetry [to achieve oxygen saturation > 90%& there after as clinically indicated Duration of NIVwas determined & clinical judgement & arterial blood gas values .

Bi-level positive airway pressure with conventional modality of therapy like oxygen ,bronchodilators, steroids ,antibiotics as needed .

Conventional mechanical ventilation was applied if above treatment strategy was deemed to have failed or pts exhibited unfavorable results like ABG parameter PaO2< 60 mmhg .PH< 7-30 with O2 supplementation .clinically tachypnoea ,use of accessory muscles of respiration ,paradoxical respiratory movement ,unstable hemodynamics ,cardiac arrhythmias ,facial deformity or tracheostomy excluded .

This study was approved by research & ethical committee of the institute in which study was done .Written permission were taken either from the patients or next of kin or legal surrogate.

DATA ANALYSIS

The RSBI was measured using a hand-held spirometer While the patient breathed through a mouthpiece, with a nasal clip on the nose to avoid air leakage. [7]

study patients were asked to breathe through the Wright spirometer for a period of 1 minute. Patient respiratory rate (RR) and tidal volume were measured by the Wright

spirometer, after which the RR value was divided by the VT value to calculate the RSBI (RR/VT). Measurement of the maximal inspiratory pressure (PImax)and the maximal expiratory pressure (PEmax) were conducted using an inspiratory force meter using the same procedures as those used for measuring the RSBI. Because all patients in the study group were suffering from acute respiratory failure, it was not feasible to occlude

the airway to obtain the measurements. Therefore, patients were asked to exhale and inhale vigorously prior to the determination of Pmax and PEmax.

the variability was deemed unlikely to introduce remarkable bias to the study results. As the Acute Physiology and Chronic Health Evaluation (APACHE)II scores were recorded for the study patients at the time of their admission to the ICU, the PImax, PEmax,

RR, VT, and RSBI measurements were repeated using the same hand-held spirometer and inspiratory force meter, prior to NIV application , and also 30 and 60 minutes subsequent to NIV application

NIPPV

All the physicians, respiratory therapists, and nurses in IRCU who were involved with the study had been well trained on the application of NIV techniquesprior to study commencement. [10] In order to facilitate comparisons between all patients, the expiratory positive airway pressure (EPAP) value was set at 4 cmH2 O without any back-up rate for all participants. and depended on the patient's tolerance to ventilation. We considered that treatment with NIV was successful if endotracheal intubation was avoided and if the patients were able to be subsequently discharged from hospital If any 1 of the following situations were detected by the physician or the respiratory therapist in charge, the NIV procedure was terminated and endotracheal intubation with invasive ventilation was immediately

commenced:

(1) decompensated respiratory acidosis featuring CO 2retention and blood pH<7.30;
(2) oxygen desaturation with an SpO2value<90% in spite of high oxygen supplementation (up to 10 L/min);
(3) inability to tolerate the NIV mask due to discomfort or pain;
(4) need for endotracheal intubation to manage secretions and/or to protect the airway; or (5) hemodynamic instability.

Data analysis

Results are expressed herein as mean± standard deviation, or mean (95% confidence interval). Differences and interval changes for serial respiratory indices (RR,VT, PImax, PEmax, RSBI) between the success and failure groups for continuous NIV application were

evaluated using Student's ttest, whilst differences in categorical data were assessed using theχ2test. Interval changes with respect to indices within each study group were evaluated using paired t tests. The independent effects of these variables on outcome were evaluated

using multivariate logistic regression analyses. All variables featuring apvalue<0.10 for the univariate analyses were included as independent variables in the initial multivariate regression model, and the final model was constructed following exclusion of the vari- ables that featured a pvalue>0.25. The area under the receiver operating characteristic curve (AUROC) for each serial respiratory index was also calculated to evaluate the capacity to predict the success of NIV treatment or otherwise. The sensitivity, specificity, positive predictive value, and negative predictive value were not reported in order to avoid dependence on a threshold .

Results

All 82 patients who satisfied the inclusion criteria agreed to participate in this study, of whom 52 [63.41%) were defined as being successful cases (the success group), and 30 (36.58%) as cases that failed NIV treatment(the failure group). The underlying diseases included pneu-monia (16 patients), chronic obstructive pulmonary disease (COPD) with exacerbation (16 patients), acute cardiogenic pulmo-

Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

nary edema (15 patients), post-extubation stridor (12 patients), and sepsis related to lung injury (9 patients) (Table 1 - 4). Among the 5 most common underlying diseases for this group of 82 patients, post-extubation stridor had the highest rate of successful NIV treatment (83.3%), followed by acute cardiogenic pulmonary edema (80%),COPD [75%] with pneumonia featuring the lowest rate of NIV treatment success (37.5%).Of the parameters measured prior to NIV treat-ment, only the APACHE II scores were significantly lower for the success group than for the failure group (p=0.001), with the AUROC value here being 0.71 (Table 6). Of the serial respiratory measurements taken, PImax30(p=0.05), RR30(p=0.01), and RR60(p=0.03) were significantly lower for the success group than for the failure group, and the corresponding AUROC values[table no 8]. When making intergroup comparison, none of the serial RSBI measurement values (taken prior to and at 30 and 60 minutes subsequent to NIV treatment) differed significantly.Amongst the interval changes for respiratory indices,PImax0–60, RR0–30, RR0–60, RSBI0–30, and RSBI0–60for the success group, and PEmax0–60, VT0–30, VT0–60, andRSBI0–60 for the failure group proved to differ statis-tically significantly (Table 3). When comparing the 2study groups, only the differences in PEmax0–60(p=0.04) and RR0–30(p=0.01) attained what we deemed to be a statistically significant level, with the AUROC values for the success and failure groups table no. 6 & 8 Predictors of successful NIV in acute respiratory failure Interval changes as regards RSBI did not differ statistically significantly between the 2 groups.

Respiratory indices (APACHE II, PImax30, RR30,RR60, PEmax0–60, RR0–30) were found to be significant in the univariate logistic regression analyses;[Table no 5] thus, all were included in the initial multivariate logistic regression model However, RR 30 was excluded due to its significant correlation to RR60 (Pearson's corre-lation coefficient=0.86;p=0.001). Further stepwise forward and backward selection excluded PImax30, so the final model included APACHE II, RR60, PEmax0–60,and RR0–30

DISCUSSION

The result of study show that NIPPV can be utilized as an effective modality of therapy in acute respiratory failure due to diverse etiology . the success rate of NIPPV treatment in our study was 63.41% which is similar to results from Number of previous studies . the success rate NIPPV was significantly higher of ARF due to post extubation stridor .acute cardiogenic pulmonary oedema ,Copd , was also revealed by the authors of number of earlier studies [5,8,13,18,19].

We have attempted to perform a comprehensive evolution of the use of respiratory indices such as Pimax, PE max,VT for predicting NIV treatment outcome .

Respiratory indices baseline prior to application of NIV ,we found APACHE II , score at presentation which is an index of the relative severity of patients illness ,differed significantly bet two groups with APACHE II values more for failure group which featured AUROC to 0.71 . A of previous studies relative to application of NIV for acute exacerbation of COPD had similar observations [11,12,13]

Patients gender & age didn't affect the outcome of NIV .

RR 30 & RR60 differed significantly bet 2 groups . [8]

In our study response to NIV treament occurred within 30 min of NIV[RR-o-30]]]] within success sp .

Although RSBI is a resembly good indicator for the weaning of patient from mechanical ventilator .[11,12]

We didn't find this parameter to be significant predictor of successful NIV –

For either serial or interval changes .In our study the improvement of RSBI were similar ,both the groups forming NIV treatment may be due to [9] simultaneous interval Improvements ,which could be related to the counter action between the improvement inRR0-30 for success group & improvement in VT0-30 for failure groups.

This can be explained probably NIV ,elicited reduction of extent of acidosis present prior to NIV treatment .The relative success of NIV treatment may be related to underlying diseases or simply to NIV treatment per se or both .

Concerning to data with early responses ,PEmax & VT improved in failure groups after NIV treatment . but not with success group . These result could be due to relative progression of preexisting--underlying lung diseases during mechanical ventilation treatment regardless of relative improvement in respiratory load .

Longer term observations of the variables as a part of future study are warranted In our study ,post-extubation stridor had higher rate of treatment success 83.3% pneumonia the lowest 37.5% . in our study cases with post extubation stridor featured improving clinical condition prior to extubation this Being the reason for which extubation was performed . general condition was relatively good so it is not surprising featured in greater success rate with NIV .Study participants with pneumonia showed downhill progression of general clinical condition which lead to ARF so less responsive to NIV treatment .[15,18,19]

Patients respiratory system is more vulnerable compared to non-pneumonia patients so because less response to NIV treatment .

COPD with acute exacerbation are individuals would appears to benefit from NIV treatment .[16,.17]

In our study didn't reveal a greater success rate with NIV treatment .

Such result might be due to the fact that COPD study participants were of older age &were bedridden .many had bronchospasms & respiratory secreations.

In our study higher AUROC values from all basic respiratory indices has for APACHE II score 0.71. Had significant differences between two groups .

No single index was able to explain the relative success of NIV treatment outcome .[19]

Past studies have shown a good level of consciousness & a lower APACHE II score at the outset of NIV treatment & extent of initial improvement in PH PaCo2& RR are predictors of NIV treatment outome.

Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

Moreover ,for NIV treatment ,BiPAP application .In emergency dept ,general wards of hospital . clinical parameters concering to patients response to NIV treatment should be explored as part further studies. since it is difficult at the outset of NIV treatment for physicians to predict which individual will benefit from NIV treatment .[14,18,19]

Table no –1, Underlying diseases amongst study participants [n= 82]

No	Diseases	Total number [n]
1	Extubation stridor	12
2	COPD	16
3	Ac.cardio pulmonary oedema	15
4	Sepsis related to lung injury	9
5	Pneumonia	16
6	Malignancy	4
7	CNS diseases	4
8	Others	6
		82

Table 2 . NIV treatment [success group]

No	Diseases	Success group	% [n=52]
1	Extubation stridor	10	19.23%
2	COPD	12	23.07%
3	Ac.cardio pulmonary oedema	12	23.07%
4	Sepsis related to lung injury	7	13.46%
5	Pneumonia	6	11.53%
6	Malignancy	2	3.84%
7	CNS diseases	2	3.84%
8	Others	3	5.76%
		52	

Table 3. NIV treatment [failure group]

No	Diseases	Failure group	% [n=30]
1	Extubation stridor	2	6.66%
2	COPD	4	13.3%
3	Ac.cardio pulmonary oedema	3	10%
4	Sepsis related to lung injury	2	6.66%
5	Pneumonia	10	33.3%
6	Malignancy	2	6.66%
7	CNS diseases	2	6.66%
8	Others	3	10%

	Diseases	Success rate %
1	Extubation stridor	83.3%
2	COPD	75.0%
3	Ac.cardio pulmonary oedema	80.0%
4	Sepsis related to lung injury	77.7%
5	Pneumonia	37.5%
6	Malignancy	50.0%
7	CNS diseases	50.0%
8	Others	50.0%

Table 5 .Parameters predicting outcome of NIV & respiratory indices between success & failure groups.[univariate & multivariate analysis]

No	Index	NIV treatment Success group	NIV treatment Failure group
1	Age [yrs]	70.7 ± 14.0	73.2 ± 13.8
2	Male/female ratio	1.04	0.94
3	APACHE II score	15.2 ± 6.5	19.8 ± 4.9
4	RR0[breaths/ min]	28.8 ± 6.9	30.6 ± 7.9
5	RR30 breaths/min	25.9 ± 5.6	28.8 ± 7.9
6	RR60[breaths/min]	24.2 ± 5. 9	29.6 ± 7.8
7	VT0 [ml]	360.5 ± 154.4	319.1 ± 137.9
8	VT30[ml]	390.4 ± 176.5	370.3 ± 175.6
9	VT60 [ml]	380.6 ± 167.5	400.2 ± 158.1
10	RSBI0[breaths/ min/ml]	100.2 ± 58.2	112.7 ± 64.4
11	RSBI30[breaths/ min/ml]	86.4 ± 50.0	100.8 ± 71.7
12	RSBI60[breaths/ min/ml]	82.8 ± 41.4	81.1 ± 40.8
13	Pimax0 [cmH2o]	-22.0 ± 14.7	_21.3 ± 16.2
14	Pimax30 [cmH2o]	-24.2 +_13.0	-20.7 ± 12.2
15	Pimax60 [cmH2o]	-25.8 ± 15.3	-21.3 ± 12.8
16	PEmax0 [cmH2o]	23.4 ± 13.8	22.2. ± 10.8
17	PEmax30 [cmH2o]	23.4 ± 12.0	24.2 ± 10.4
18	PEmax60 [cmH2o]	25.2 ± 12.6	28.9 ± 13.4

APACHE II – acute physiology & chronic health evaluation

Pimax –maximum inspiratory pressure ,Pemax –maximum expiratory pressure

RR – respiratory rate ,VT –Tidal volume, RSBI –Rapid shallow breathing index

Table 6. Parameters predicting outcome of NIV & respiratory indices between success & failure groups.[univariate & multivariate analysis

No	Index	P at difference	AUROC
1	Age [yrs]	0.41	0.55
2	Male/female ratio	0.81	
3	APACHE II score	0.001	0.70
4	RR0[breaths/ min]	0.29	0.56
5	RR30 breaths/min	0.01	0.66
6	RR60[breaths/min]	0.04	0.60
7	VT0 [ml]	0.29	0.57
8	VT30[ml]	0.75	0.53
9	VT60 [ml]	0.50	0.57
10	RSBI0[breaths/min/ml]	0.31	0.57
11	RSBI30[breaths/min/ml]	0.20	0.56
12	RSBI60[breaths/min/ml]	0.80	0.52
13	Pimax0 [cmH2o]	0.42	0.56
14	Pimax30 [cmH2o]	0.05	0.65
15	Pimax60 [cmH2o]	0.12	0.60
16	PEmax0 [cmH2o]	0.25	0.54
17	PEmax30 [cmH2o]	0.66	0.50
18	PEmax60 [cmH2o]	0.38	0.54

Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

Table 7. Clinical parameters &respiratory indices prior to & at 30& 60minutes subsequent to noninvasive ventilation [NIV] treatment .

No		NIV treatment Success group	NIV treatment Failure group
1	RR0-30[breaths/ min]	-2.8[4.1- -1.8]	-0.8[-2.0-0.4]
2	RR30- 60 breaths/min	0.1[-0.8-1.0]	-0.2[-2.0-1.5]
3	RR60-90[breaths/min]	-2.8[-4.2- -1.1]	-1.0[-3.0-0.9]
4	VT0-30 [ml]	30.1[-6.3-68.6]	51.3[18.6-83.9]
5	VT30-60[ml]	0.0[-33.4 -33.4]	3.9[-27.7-35.4]
6	VT60-90 [ml]	22.5[- 11.9-58.8]	71.0[33.9- 108.2]
7	RSBI0[breaths/min/ml]	-16.5[28.0- -5.2]	-12.0[-26.9- 3.0]
8	RSBI30[breaths/min/ml]	-3.3[-11.2-2.5]	-3.2[-11.7-5.3]
9	RSBI60[breaths/min/ml]	-16.7[27.3-6.4]	-20.9[-32.4- -9.4]
10	Pimax0-30 [cmH2o]	-2.9[-5.5-0.0]	0.6[-5.0-6.2]
11	Pimax30-60 [cmH2o]	-1.4[3.8-0.9]	-9.7[-3.0-1.6]
12	Pimax60-90 [cmH2o]	-4.0[-7.0- -1.0]	-2.6[-5.9-0.6]
13	PEmax0-30 [cmH2o]	0.5[-1.8- 3.1]	2.1[- 0.7- 4.8]
14	PEmax30-60 [cmH2o]	0.4[-1.4- 2.4]	3.4[-0.3- 7.0]
15	PEmax60 - 90[cmH2o]	1.0[- 1.9- 4.2]	6.0[2.7-9.4]

Table 8 Clinical parameters &respiratory indices prior to & at 30& 60minutes subsequent to noninvasive ventilation [NIV] treatment

No		P at difference	AUROC
1	RR0-30[breaths/ min]	0.01	0.67
2	RR30- 60 breaths/min	0.67	0.53
3	RR0-60[breaths/min]	0.21	0.58
4	VT0-30 [ml]	0.47	0.55
5	VT30-60[ml]	0.87	0.50
6	VT0-60 [ml]	0.11	0.64
7	RSBI0[breaths/min/ml]	0.62	0.47
8	RSBI 30-60[breaths/min/ml]	0.83	0.52
9	RSBI0-60[breaths/min/ml]	0.64	0.52
10	Pimax0-30 [cmH2o]	0.21	0.61
11	Pimax30-60 [cmH2o]	0.67	0.53
12	Pimax60-90 [cmH2o]	0.56	0.54
13	PEmax0-30 [cmH2o]	0.43	0.54
14	PEmax30-60 [cmH2o]	0.14	0.57
15	PEmax60 - 90[cmH2o]	0.05	0.60

AUROC – Area under the receiver operative curve, p< 0.05 within the NIV treatment success & failure groups

Table 9. Odds ratio[OR] & confidence intervals 95 % [CI] for the success group

No	Parameters	OR	95% CI	P
1	APACHE II Score	0.023	0.001 – 0.545	0.02
2	RR 0-30 [breaths /min]	0.024	0.000 – 0.715	0.05
3	RR 60[breaths /min]	0.013	0.000 – 0.633	0.04
4	PImax [cmH2O]	0.238	0.004 – 7.594	0.44
5	PEmax0-60 [cmH20]	0.016	0.000 – 0.704	0.05

OR – Odd's ratio & CI – Confidence intervals [95%] obtained from logistic regression analysis system .

Conclusion –

Documented /recorded APACHEII score prior to NIPPV ,PIMAX 30, RR30, RR60,Improvements in RR during first 30 mins of NIPPV & PEmax during first 60 mins Of NIV treatment were predictors of successful NIV treatment in patients with ARF .

So NIPPV is effective in avoiding endotracheal intubation in ARF due to post extubation stridor ,respiratory failure, acute cardiogenic oedema, COPD.

Volume : 5 | Issue : 6 | June 2015 | ISSN - 2249-555X

REFERENCE

1. Liesching, T, Kwok, H, Hill, NS. Acute applications of noninvasive positive pressure ventilation. Chest. 2003;124:699–713 | 2. Brochard L, Mancebo J, Elliott MW. Noninvasive ventilation for acute respiratory failure. Eur Respir J. 2002;19:712–21. | 3. Brochard L. Mechanical ventilation: invasive versus noninvasive. Eur Respir J. 2003;23(Suppl 47):S31–7. | 4. Ram FSF, Picot J, Lightowler J, et al. Non-invasive positive pressure ventilation for treatment of respiratory failure due to exacerbations of chronic obstructive pulmonary disease. Cochrane Database Syst Rev. 2004;3:CD004104. | 5. Pang, D, Keenan, SP, Cook, DJ. The effect of positive pressure airway support on mortality and the need for intubation in cardiogenic pulmonary edema: a systematic review. Chest. 1998;114:1185–1192kinnan | 6. Agarwal R, Reddy C, Aggarwal AN, et al. Is there a role for noninvasive ventilation in acute respiratory distress syndrome? A meta-analysis. Respir Med. 2006;100:2235–8 | 7. Yang, KL, Tobin, MJ. A prospective study of indexes predicting the outcome of trials of weaning from mechanical ventilation. N Engl J Med. 1991;324:1445–1450 | 8. Girault, C, Briel, A, Hellot, MF. Noninvasive mechanical ventilation in clinical practice: a 2-year experience in a medical intensive care unit. Crit Care Med. 2003;31:552–559 | 9. Krieger, BP, Isber, J, Breitenbucher, A. Serial measurements of the rapid-shallow-breathing index as a predictor of weaning outcome in elderly medical patients. Chest. 1997;112:1029–1034 | 10. Antón, A, Guell, R, Gomez, J. Predicting the result of noninvasive ventilation in severe acute exacerbations of patients with chronic airflow limitation. Chest. 2000;117:828–833. | 11. Plant PK, Owen JL, Elliott MW. Early use of non-invasive ventilation for acute exacerbations of chronic obstructive pulmonary disease on general respiratory wards: a multicentre randomised controlled trial. Lancet. 2000;355:1931–5. | 12. Plant PK, Owen JL, Elliott MW. Non-invasive ventilation in acute exacerbations of chronic obstructive pulmonary disease: long term survival and predictors of in-hospital outcome. Thorax. 2001;56:708–12. | 13. Ambrosino, N, Foglio, K, Rubini, F. Non-invasive mechanical ventilation in acute respiratory failure due to chronic obstructive pulmonary disease: correlates for success. Thorax. 1995;50:755–757. | 14. Wood KA, Lewis L, Von Harz B, et al. The use of noninvasive positive pressure ventilation in the emergency department: results of a randomized clinical trial. Chest. 1998;113:1339–46. | 15. Confalonieri, M, Potena, A, Carbone, G, Porta, RD, Tolley, EA, Umberto Meduri, G. Acute respiratory failure in patients with severe community-acquired pneumonia. A prospective randomized evaluation of noninvasive ventilation. Am J Respir Crit Care Med. 1999;160:1585–1591. | 16. George IA, John G, John P, et al. An evaluation of the role of noninvasive positive pressure ventilation in the management of acute respiratory failure in a developing country. Indian J Med Sci. 2007;61:495–504. | 17. Lightowler JV, Elliott MW. Predicting the outcome from NIV for acute exacerbations of COPD. Thorax. 2000;55:815–6.] | 18. Phua J, Kong K, Lee KH, et al. Noninvasive ventilation in hypercapnic acute respiratory failure due to chronic obstructive pulmonary disease vs. other conditions: effectiveness and predictors of failure. Intensive Care Med. 2005;31:533–9. | 19. Nava S, Ceriana P. Causes of failure of noninvasive mechanical ventilation. Respir Care. 2004;49:295–303 |