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A prospective cross-sectional study of incidence of difficult airway in intensive care unit in North India

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Abstract
Background: Airway management is commonly performed procedures in the intensive care unit (ICU). Difficult airway along with hypoxemia and cardiovascular collapse is most serious life - threating complication in critically ill patients. Average incidence of difficult airway is around 10 to 23% depending on protocols followed by the institute and availability of equipment's in the centre. The aim of this study is to find out the incidence of difficult airway and to develop a score that predict difficult airway in critical care unit.
Method and Material: A Prospective study was conducted in tertiary care hospital and attached medical college for a period of two year (from July 2017 to July 2019) in 30 bedded mixed ICU and 9 bedded cardiac care unit, in patients of age group (18-90 year) who require mechanical ventilatory support. The airway management in ICU was done by an experienced anaesthetist or intensivist having work experience of more than five years.
Results: In two-years, total 3,504 patients admitted in our ICU and out of them 1872(53.42%) patients require invasive ventilatory support. Anatomical difficult airway was encountered in total 504 (26.92%) patients, out of which 281 (55.75%) were male and 223 (44.24%) were female. DBMV is seen in 167 (8. 92%) patient, DSDP in 79 (4.22%), DI in 161 (8.6%), DSA in 97(5.18%) of the patients and physiological difficult airway (PDA) in 1204 (64.31%) patients and anatomical with physiological difficult airway (ADA+PDA) was found in total 164(8.76%) patients. In our study 8.76% was very difficult due to anatomical and physiological reasons, 26.92% was difficult due to anatomical factors of patients and 64.31% are moderately difficult due to physiological factors associated with underlying disease of the patients.
Conclusion: Incidence of difficult airway is very high in ICU as compare to OT due to anatomical factors and physiological factors of the patients, so each and every patient requires different strategies of airway management in ICU.

Keywords: Difficult airway, anatomical, physiological, bag and mask, supraglottic device, surgical, invasive ventilator

Introduction
ICU harbours patients with severe or life -threating illness or injuries requiring continuous care, close monitoring using life support equipment's and medications to ensure normal body functions. Majority of ICU patients require mechanical ventilation support to assist breathing through an endotracheal tube [ET] or a tracheostomy tube [TT]. Endotracheal Intubation[EI] is high-risk procedure associated with high mortality rate in ICU as compare to Operation Theatre [OT] because ICU patients are hemodynamically unstable having hypoxemia, metabolic acidosis, raised intracranial pressure, and coagulopathy and are prone for hypotension and hypoxemia in the immediate post-intubation phase due to blunting of compensatory sympathetic response, thus requiring significant expertise in airway handling as well as understanding of pathophysiology of the disease process. Airway-related events in ICU are potentially fatal, thus giving minimal margin of error to the intensives [1, 2, 5].
Difficult airway encountered in terminally ill patients is called Physiological Difficult Airway [PDA] because various pathophysiological changes pertaining to disease process in body like alveolar flooding causing loss of alveolar capillary interface along with relative fluid deficit, neuromuscular fatigue and coexistent organ dysfunction, so the induction and intubation can be potentially life threatening due to reduced physiological reserves [3].Anatomical difficult airway [ADA] is another common problem encountered by anaesthetist and intensivist. The term ADA is used when there is difficulty in bag mask ventilation or in inserting supraglottic airway device or in visualisation of glottic opening or passing of endotracheal tube through the opening. Awake intubation is gold standard.

Technique in ADA, while in PDA, it can worsen the patient condition as inadequate blunting of airway reflexes can cause rise in intracranial pressure or worsen cardiac ischemia in the predisposed individuals. Moreover, baseline physiological derangements worsen with increased number of attempts to intubate [4]. Therefore, airway strategy with highest rate of first pass success is important in management of critically ill patients. There can be another group of patients who have anatomically as well as physiologically difficult airway [Table 1]. One can intuitively understand that a common approach of induction and intubation cannot be used for all types of conditions and specific subgroups require specific strategy modification. Fourth National Audit Project of The Royal College of Anaesthetists and The Difficult Airway Society reported that 61% of airway-related events in ICU were associated with death or permanent neurological damage compared with 14% in operating room [5].

The Aim of this study is to find out the incidence of difficult airway and identify the common causes of difficult airway and their management in critically ill patients in Tertiary Care Centre in Western India

Method and Materials

This study is conducted in 30 bedded mixed ICU and 9 bedded cardiac care unit (CCU) of tertiary care centre after taking approval from Institute ethical committee for a period of two year (from July 2017 to June 2019). This is mixed ICU in which patients from all departments like general medicine, general surgery, orthopaedics and trauma, neurosurgery, neurology, onco-surgery, respiratory medicine, urology, gynaecology, nephrology, and patient with cardiac problem keep in CCU. Around 146 patients are admitted in our ICU per month, out of which around 78 patients required intubation and ventilatory support due to acute respiratory failure with COPD, chronic kidney disease with pulmonary oedema, trauma with multiple bone fracture, head injuries with cervical spine injuries, septic shock with multiorgan dysfunction, congestive heart failure, liver cirrhosis with portal hypertension with hypotension, and other medical illness.

Patient's selection criteria

1. Only critically ill patient admitted in ICU and who require intubation
2. Age group 18 to 90 years

Table 1: Classification of difficult airway

Anatomically difficult airway (ADA)	Physiologically difficult airway (PDA)	Anatomically as well as physiologically difficult airway
1.Difficult bag mask ventilation [DBMV]	1. Neurophysiologic derangement (raised intracranial pressure)	1+ (Any in PDA 1 To 8)
2.Difficult supraglottic device placement [DSDP]	2. Cardiovascular derangement (derangements of preload, afterload, contractility or rhythm)	2+(Any in PDA 1 To 8)
3.Difficult intubation [DI]	3. Respiratory derangement (hypoxemia and hypercarbia	3+(Any in PDA 1 To 8)
4.Difficult surgical airway [DSA]	4. Hepatic derangement (raised intra hepatic pressure and coagulopathy)	4+(Any in PDA 1 To 8)
	5. Renal derangement (encephalopathy, pulmonary oedema, hyperkalaemia and metabolic acidosis)	
	6. Gut derangement (raised intra-abdominal pressure, abdominal compartment syndrome)	
	7. Severe sepsis (lactic acidosis, distributive shock, multiple organ dysfunction	

Method of intubation

Equipment's used in ICU for airway management-

1. Capnography- must be used for confirmation of correct position of EI
2. Difficult airway Trolley and Bronchoscope- For immediate management of DI
3. Metal blade for direct laryngoscopy -like Macintosh, Mc-coy, and Magill of all sizes to improve the success rate of EI.
4. Video laryngoscopes (VL) - for intubation in ICU must be used either initially or after failure of direct laryngoscopy.
5. Supraglottic devices (SGD) - must be used in the management of difficult intubation, to oxygenate the patient, and facilitate intubation under bronchoscope control.

Drugs used in ICU for intubation

1. Hypnotic agents- Propofol, Ketamine, Etomidate to facilitates induction, choice depends on patient clinical condition.
2. Succinylcholine to facilitate tracheal intubation during RSI (rapid sequence induction)
3. Rocuronium at a dose above 0.9 mg/kg [1.0–1.2 mg/kg] should be used when succinylcholine is contraindicated.
4. Sugammadex- for reversal of neuromuscular blockade should probably be rapidly available when rocuronium is used.

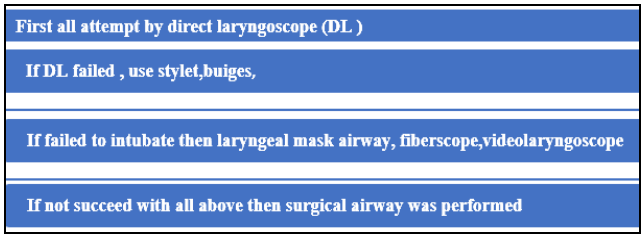
Protocols of Airway management in ICU patient

In critically ill patients requiring ICU admission, monitor is attached to record vital parameter like ECG, HR, NIBP, Spo2, RR. After inserting Intravenous cannula, blood samples sent in central lab for renal function test (RFT), liver function test (LFT), CBC, Coagulation profile, Serum electrolytes, arterial blood gas (ABG) and then IV Fluid started.

On the basis of clinical parameters and ABG report, patients requiring invasive ventilatory support were pre-oxygenated by use of Non-invasive ventilation and induction with

hypnotic agents and neuromuscular blockade was done according to clinical condition of the patients. EI was performed by experienced anaesthesiologist having experience of more than five-years.

Algorithm used for intubation in ICU



Patient's performa is filled including patient name, age, gender, BP, PR/HR, RR, spo2, type of difficult intubation as describe in table no [1], and out-come of patients.

Statistical analysis

The data obtained was coded and entered in to Microsoft excel Worksheet and the data was analysed by using rate, ratio, percentage, and proportion.

Results

In two Year, total, 3,504 patients admitted in our 39 bedded ICU, out of them 1872 patients require invasive ventilatory support, out of 1872, ADA was found in 504 (26.92%) patients and PDA in 1204 (64.31%) patients and anatomical with physiological difficult airway (ADA+PDA) was found in total 164(8.76%) patients [Figure 1]

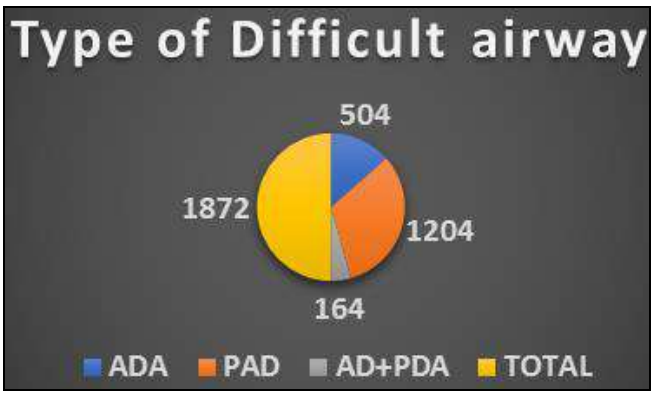


Fig 1: Distribution of Difficult airway in ICU

Table 2: Distribution of Incidence of ADA in ICU]

Age(year)	DBMV		DSDP		DI		DSA		Total	
	M	F	M	F	M	F	M	F	M	F
18-40	11	10	6	8	14	10	11	5	42	33
41-60	16	14	12	8	19	18	12	11	59	51
61-80	34	24	11	10	24	20	11	14	80	68
>81	38	20	12	12	32	24	18	15	100	71
M/F	99	68	41	38	89	72	52	45	281(55.75%)	223(44.24%)
Total	167(8.92%)		79(4.22%)		161(8.6%)		97(5.18%)		504(26.92%)	

[DBMV-Difficult bag mask ventilation, DSDP- Difficult supraglottic device placement, DI- Difficult intubation, DSA- Difficult surgical air-way]

ADA is noted in total 504 (26.92%) of the patients, out of them 281 (55.75%) were male and 223 (44.24%) were female, M/F ratio was, 1.26. DBMV were seen in 167 (8. 92%%) patient, DSDP in 79 (4.22%), DI in 161 (8.6%), DSA in 97(5.18%) of the patients. Most common age group having DBMV >81year, 38 (13.52%) male followed by 61-80year male 34(12.09%) and DSDP is also common in age group 61 to>81yeras male, and DI is also most commonly noted in male >81 years, 32(11.38%) followed by 61-81year male, 24(8.54%). DSA was noted in age group 61to >81 year. [Table -2, Figure -2].

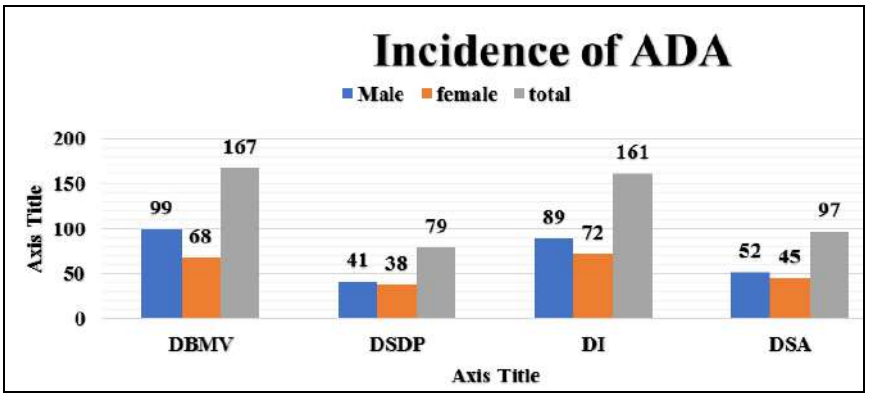


Fig 2: Distribution of Incidence of ADA in critically ill patients

Incidence of PDA is around 1204(64.31%), out of them 804(66.77%) were male and 400 (33.22%) were female, M/F ratio was 2.01, most common difficulty in intubation were faced in patient with raised ICT 260 (13.88%) followed by renal derangement 224(11.96%) and Gut derangement 188(10.04%) [Table-3]. 164(8.76%) patients having ADA as well as PDA, out of them 155 patients having DBMV+PDA (8.27%) and 9(0.48%) patients having DI+PDA. There is not a single patient noted with DSDP with PDA and DS+PDA in our critical care unit.

Table 3: Distribution of Incidence of PDA in ICU

Physiological difficult airway	male	female	total
1.Neuro-physiologic derangement (raised intracranial pressure)	180	80	260(13.88%)
2.Cardiovascular derangement (derangements of preload, afterload, contractility or rhythm)	110	54	164(8.76%)
3.Respiratory derangement (hypoxemia and hypercarbia	124	42	166(8.86%
4.Hepatic derangement (raised intracranial pressure and coagulopathy)	68	24	92(4.91%)
5. Renal derangement (encephalopathy, pulmonary oedema, hyperkalaemia and metabolic acidosis)	156	68	224(11.96%)
6.Gut derangement (raised intra-abdominal pressure, abdominal compartment syndrome)	108	80	188(10.04%)
7.Severe sepsis (lactic acidosis, distributive shock, multiple organ dysfunction	58	52	110(5.87%)
Total	804(66.77%)	400(33.22%)	1204(64.31%)

Table 4: Distribution of Incidence of DBMV + PDA

Difficult airway	Male	Female
DBMV+ Raised ICT	22 (13.4%)	6
DBMV+ Raised IAP	19 (11.58%)	8
DBMV+PE	7 (4.26%)	6
DBMV+SEPSIS	16 (9.75%)	4
DBMV+ Respiratory distress	18 (10.97%)	6
DBMV+ Hepatic	10 (6.09%)	8
DBMV+ Cardiac cause	16 (9.75%)	9
Total	108 (65.85%)	47(28.65%)

[ICT-Intracranial Tension, IAP-Intraabdominal pressure, PE-pulmonary embolism,]

DBMV+PDA is seen in total 155(8.27%) of patient, out of them 108(65.85%) were male and 47(28.65%) were female, M/F ratio was 2.29. Most common condition cause difficult airway in ADA+PDA was raised ICT with DBMV, was seen in 22 (13.4%) male followed by DBMV+ raised IAP 19(11.58%) male and DBMV+ Respiratory distress 18(10.97%) male, DBMV+ sepsis 16(9.75%) male, DBMV+ Cardia 16(9.75%) male patients [Table -4]. DI+ PDA was noted in 9(5.48%) male patients, out of them 6(3.65%) male patients had DI with raised IAP followed by DI with respiratory distress 2(1.21%), and DI with sepsis 1(0.6%) male patient [Table 5]

Table 5: Distribution of Incidence of DI+PAD

DI+PDA	Male	Female
DI+IAP	6(3.65%)	0
DI+ respiratory distress	2(1.21%)	0
DI+ Sepsis	1(0.6%)	0
Total	9(5.48%)	0

In our study 8.76% was very difficult airway due to anatomical and physiological reasons, 26.92% was difficult due to anatomical factors of patients and 64.31% are moderate difficult due to physiologically factors of the patients in ICU.

Discussion

There are many complications associated with difficult intubation due to severe hypoxia and cardiovascular collapse in ICU like cardiac arrest, cerebral hypoxia and death. To prevent and limit the incidence of difficult intubation, specific risk factors for difficult intubation in the ICU have been identified and pre-oxygenation techniques and intubation algorithms have been developed. According to (De Jong *et al*.2013b) [6] average incidence of difficult intubation is 10% and it's range from 1% to 23% depending on the centre and the definition used (Martin *et al*. 2011; Heuer *et al*. 2012; Simpson *et al*.; 2012; Le Tacon *et al*. 2000) [7, 8, 9, 10]. In ICU difficult Airway (DA) may be because of anatomical difficult (AD), physiologically difficult (PD), and both (AD+PD) the condition. In our study the incidence of ADA was 26.92% and PDA in 64.31%patients and anatomical with physiological difficult Airway in total 8.76% patients. This is favoured by a study conducted by (Heuer JF *et al*.2012) showed that 30% intubations in ICU was easy, 47% of intubation was moderate easy, 23% was difficult intubation in ICU [11]. ADA was found in 26.92% (N=504) of patients in our study. DBMV was found in total 8. 92% (n=167) of the patients. Yildiz TS *et al*. [12] study results are in favour of our study results, according to that incidence of difficult mask ventilation in general was 7.8% (n = 45), and the incidence of DMV among patients with difficult intubation (n = 123) was found to be 15.5% (n = 19). Old age, male gender, increase Mallampati class 3- 4, history of snoring, lack of teeth, and beards, body mass index 30 or more, neck mass or radiation, limited thyromental distance, sleep apnoea were found to be significantly associated risk factors for DMV [13, 14] Prerana N Shah *et al*. found in their study that DBMV and DI was common in patients with h/o snoring and anatomical abnormalities of face and neck. BMI > 26 kg/m ^{2} along with atlantooccipital extension grade > 3 were independent risk factors for DI [14]. DI noted in 8.6% of the patients in our ICU, DSDP are in 4.2% of the patients and 5.18% of had DSA. We all know that difficult intubation is significantly higher in the ICU setting compare to operating room because airway assessment is not possible in ICU patients as patients admitted on emergency basis. Study conducted by Jaber *et al*. described that intubation in critically ill patients are associated with severe life threating complication, if the indications for intubation are presence of acute respiratory failure, shock and coma. The defined complication observed in this study are severe hypoxemia (26%), hemodynamic collapse (25%), cardiac arrest (2%), difficult intubation (12%), cardiac arrhythmia (10%), oesophageal intubation (5%), and aspiration (2%) [15]. Schwartz *et al*. found that intubation to be difficult in nearly 8% of the critically ill patients and requiring more than two attempts at laryngoscopy by a physician skilled in airway management. Oesophageal intubation occurred in 8% of the patients, pulmonary aspiration was present on chest radiography after 4% of intubations. Mortality associated with emergent tracheal intubation is highest in patients who are hemodynamically unstable and receiving vasopressor therapy before intubation [16] Le Tacon *et al*. found DI in 22.5% of patients in ICU and concluded that a special airway management protocol must be developed in critical care unit in order to reduce the rate of DI [17]. A Study published by Griesdale described an incidence of difficult intubations and serious complications is high in critically ill and they found DI incidence in ICU patients is only 6.6% [18] DI incidence is 8.6% in patients admitted in our ICU, and it is near to above mentioned study. Supraglottic airway

device is an important part of difficult airway cart to maintain ventilation and oxygenation. A study performed by T. Sait *et al*. described four risk factors for difficult ventilation via a supraglottic airway device including male gender, age >45year, short thyromental distance, and limited neck movement. Incidence of complications associated with DSDP are 22%, including oxygen desaturation, hypercapnia, laryngospasm, and bronchospasm and the incidence of difficult ventilation via a supraglottic airway device was 0.5%. But in our study DSDP incidence was 4.2% in critically ill patients. This is because in ICU and in emergency department most of the patients require airway managements as a result of acute medical or surgical conditions which by themselves contribute to the difficulty. In this prospective study we observed that ADA is might be considered in these areas: DBMV, DI, DSDP, DS. The incidence of DSA in our study is around 5.18% while a study performed by

Evelyn Wong and Yih-yng Ng difficult surgical airway rate was 0.3%, half of which were cricothyroidotomies and half were tracheostomies. The important causes of difficult cricothyroidotomy and difficult tracheostomies are anterior neck swellings, infections, obesity, short neck, injuries of cervical spine, post-radiation therapy as well as main stem bronchial and tracheal injuries. The incidence of difficult surgical airways is unknown till date [20].

Physiologically difficult airway

Physiologically difficult airway is very common condition faced by intensivist, because the process of induction and intubation can be potentially life threatening due to reduced physiological reserves pertaining to disease process [21]. So intubation must be in single attempt and less time consuming in critically ill patients as baseline physiological derangements worsen with increased number of attempts to intubate [22]. The incidence of PDA is around 64.31%patients in our ICU and it is considered as moderately difficult intubation because ICU patients are under physiological stress due to their underlying disease. Many of them are in compensatory state of their physiological derangement of existing disease. So the use of induction agents in these patients lead to "physiological compensation blunting or failure". As a result, patient may undergo acute changes in hemodynamic and metabolic milieu at the time of induction and intubation [23] Current guidelines recommend 3 min of preoxygenation in critically ill patients, which should be done if possible by using non-invasive positive pressure ventilation (inspiratory pressure 5 to 15 cm, PEEP 5 cm and target tidal volume 6 to 8 ml/kg) in a head up position or with high-flow nasal cannula with oxygen flow at 70 L per min [24].

Difficult airway (DA) due to neurophysiological derangement: Traumatic brain injury and stroke patients requiring intubation and mechanical ventilation form a specific subgroup where raised intracranial pressure is the key physiological derangement. These patients also show wide fluctuation of blood pressure during rapid sequence induction and intubation [25].

DA in cardiac patients

Intubation in cardiac patients requires preload, afterload, heart rate and contractility optimization. Cardiac tamponade forms a specific subgroup where intubation should be delayed till definitive management of cardiac tamponade is achieved. Management goals in patients at high risk for myocardial ischemia are avoiding increase in heart rate and factors that cause extreme increase in wall stress, i.e. inotropes and afterload [26], Patients with stenotic lesions are most challenging to manage. Hemodynamic goals in management of mitral stenosis include prevention of increase in pulmonary artery pressures, heart rate and marked afterload reduction. Aortic stenosis requires heart rate control, adequate preload and avoidance of myocardial ischemia.

Difficult airway due to respiratory derangement: ARDS patients are prone to acute right ventricular dysfunction. If time permits screening, bedside ECHO should be done to evaluate right ventricle. Invasive hemodynamic monitoring is preferable at the time of induction in patients with concomitant cardiac and respiratory failure. Intubation in patients with right ventricular failure is extremely risky because unlike left ventricular function, right ventricular function deteriorates with increased intra-thoracic pressure caused by positive pressure ventilation. Right ventricular preload and afterload optimization is needed before intubation in order to prevent cardiovascular collapse. Methods of right ventricular afterload optimization include inhaled pulmonary vasodilators like nitric oxide or epoprostenol, correction of hypoxic pulmonary vasoconstriction by oxygen supplementation and decreasing atelectasis via non-invasive ventilator support [27, 28].

Difficult airway due to hepatic derangement: Hepatic failure patients have raised ICP due to hepatic encephalopathy. They should be intubated with neuron protective strategy. Moreover, they have coagulopathy and are frequently thrombocytopenic. Suboptimal intubating conditions can lead airway trauma and bleeding, thus making physiologically difficult airway also anatomically difficult. Nasal intubation should not be used in these patients in view bleeding tendency. Blood product transfusion should be considered in patients with high risk of bleeding.

Difficult airway due to renal derangement: Renal failure patients may require intubation due to increased work of breathing caused by severe metabolic acidosis. These patients maintain their pH within normal range by increasing minute ventilation and washing out carbon dioxide. Induction of anaesthesia causes fall in minute ventilation and loss of compensatory response. Using neuromuscular blocking drug can further bring down the pH and cause precipitous fall in blood pressure and dangerous rise in potassium concentration. These patients should be intubated keeping rapid changes in metabolic milieu in mind. Succinylcholine should be avoided in renal failure as it causes hyperkalaemia [29].

DA due to gut dysfunction: ICU patients may suffer from paralytic ileus, ascites, pseudo-obstruction and raised intra-abdominal pressure. All these factors predispose for vomiting and aspiration till the airway is secured with cuff inflation. Rapid sequence induction is the preferred mode. Fluid shifts in patients in paralytic ileus, pancreatitis and intestinal obstruction predispose for hypotension during induction.

DA due to sepsis: Sepsis patients are prone for distributive shock. Hemodynamic instability, lactic acidosis and coagulopathy are frequent issues. Volume resuscitation and vasopressor form the key components of airway management strategy. Optimal venous access should be secured before induction in these patients. Invasive hemodynamic monitoring is preferable in patients requiring high-dose noradrenaline. Etomidate can cause cortisol insufficiency. Ketamine is the preferred agent for induction.

Conclusion- We conclude that incidence of difficult airway is more in critically ill patients compared to elective patients posted in OT due to previously no assessment of anatomical as well as physiological factors of the underlying disease. Thus, each and every patient admitted in ICU must be treated as a case of difficult airway, keeping all the equipment and drugs ready for difficult airway management.

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