Low Pressure Cuff Tracheal Tubes

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Endotracheal tubes (ETT) with low pressure cuffs generate low ETT cuff pressures (ETCP). But at times ETCP can be in high and unsafe levels, which can cause ischaemic pressure damage of trachea. Aim of the study was to achieve safe levels of ETCP during operations. We prospectively studied ETCP in 80 patients undergoing elective cholecystectomy. After tracheal intubation the ETT cuff was inflated by the anaesthesia technician to the satisfaction of the attendant anaesthetist. ETCP was measured 10 minutes after intubation, if high it was brought down to 25 cm H2O. Leak and reduction in expired tidal volume was looked for. Extra air was added to the cuff to correct this. ETCP was measured again. Safe levels of ETCP (≤25 cmH2O) were found in 47.5% patients. Unsafe levels of ETCP were found in 52.5% patients. When ETCP was adjusted down to 25 cm H2O in these patients, it showed that another 45% patients could have had leak proof ventilation within the safe levels of ETCP. Only 7.5% patients needed slightly high levels (32.5 cmH2O) of ETCP. High Volume Low Pressure (HVLP) cuff tracheal tubes can also generate high and unsafe ETCP. There is need to monitor ETCP regularly.

Key words: - Endotracheal tubes; cuff pressures; low pressure cuffs; monitoring.

Tracheal intubation is a common procedure for patients getting anaesthesia, in intensive care and in the accident and emergency departments. The advantage of the cuffed tracheal tubes include: (i) provision of leak proof ventilation, (ii) prevention of aspiration of foreign material into the lungs and (iii) the cuff keeps the tube in the centre of the trachea.

Tracheal complications still occur despite the use of High Volume Low Pressure (HVLP) endotracheal tubes (ETT). A common site of tracheal injury is the area where the inflated cuff of ETT makes contact with the trachea.

Under normal hemodynamic conditions the mean systemic capillary pressure is 25 mm Hg (=30 cm H2O)' (fig.1) Nordin found that the capillary pressure in the tracheal mucosa lies between 20 to 30 mm Hg. For HVLP cuffs, the ETCP equals the mucosal contact pressure. Joh S.' (1987) has suggested to keep the mucosal contact pressure (i.e. ETCP) at or below 20 mm Hg (= 27 cm H2O) to prevent cuff-pressure induced ischaemic injury to tracheal mucosa. Ischaemic changes may occur in tracheal mucosa within 15 minutes if the ETCP is greater than 30 mm Hg (40 cm H2O)²

Figure 1. Normal capillary circulation (Guyton A.C³)

Material and Methods:
After the departmental permission and informed consent, eighty patients undergoing elective cholecystectomy were studied in Services Hospital, Lahore. These patients were of ASA I and II status.

Patients with preoperative assessment of difficult airway were excluded. There were 15 (18.75%) male and 65 (81.25%) females. Their age was between 35 to 50 years (mean age 42.5 years).

All the patients were assessed by the anaesthetist preoperatively. They were premedicated with lorazepam 1 mg the night before surgery. The anaesthetic management was similar, which included the following - On arrival of the patient in the operation theatre, intravenous cannula secured: Electrocardiogram, non invasive blood pressure, pulse oximetry, ventilator alarm and expired tidal volume were monitored. After preoxygenation, anaesthesia was induced using morphine (0.1mg/kg), deep dose of thiopentone and pancuronium bromide (0.1 mg/kg). Trachea intubated with a high volume, low pressure cuff tube (Mallinckrodt). ETT cuff was inflated by the anaesthesia technician to the satisfaction of the attendant anaesthetist. Intermittent positive pressure breathing was intubated, using oxygen, medical air and halothane. Additional pancuronium was used as necessary. Intravenous fluids were given according to the patients clinical needs. At the end of operation muscle paralysis was reversed, using neostigmine and atropine. Trachea was extubated when the patients fulfilled the extubation criteria. All patients were kept in the recovery area before being taken back to their surgical wards.

Endotracheal tube cuff pressures (ETCP) were monitored and studied in all these patients using cuff inflator / pressure gauge (Portex 100/568/000). First
readings were obtained ten minutes after tracheal intubation. If the initial ETCP was equal to or less than 25 cm H2O, it was left alone. If the initial ETCP was more than 25 cm H2O, the ETT cuff was deflated down, to 25 cm H2O. At this point, I looked for any audible leak of gas around the tube and any reduction in expired tidal volume. Extra air was injected into the tube cuff so as to stop the leak and fall in the expired tidal volume. ETCP was noted once again at this point.

Results:
Eighty adult ASA I and II status patients were studied while undergoing elective cholecystectomy. There were 81.25% (65) females and 18.75% (15) males. Their age was between 35 and 50 years (Table I).

Table I: Demographic Data (n=80)

<table>
<thead>
<tr>
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<th>Total Patients</th>
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<tr>
<td>Male</td>
<td>35 (41.25%)</td>
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<tr>
<td>Female</td>
<td>45 (58.75%)</td>
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Age: 35 - 50 years, Mean age: 42.5 years

The first measurement of ETCP was taken after 10 minutes of tracheal intubation. ETCP of 25 cm H2O or less was found in 47.5% (n=38; Table II) patients.

Table II: Initial ETCP (Min=8 Max=60) cm H2O

<table>
<thead>
<tr>
<th></th>
<th>Normal ETCP</th>
<th>High ETCP</th>
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<tbody>
<tr>
<td>% age</td>
<td>≤ 25 cm H2O</td>
<td>26 to 60 cm H2O</td>
</tr>
<tr>
<td>Male</td>
<td>47.5% (n=38)</td>
<td>52.5% (n=42)</td>
</tr>
<tr>
<td>Female</td>
<td>16.25% (n=13)</td>
<td>2.5% (n=2)</td>
</tr>
</tbody>
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In 52.5% (n=42) patients the initial ETCP was in the high range of 26 to 60 cm H2O (Table III). When the ETCP in these patients was brought down to 25 cm H2O, audible leak of gas and a fall in the expired tidal volume was noted in 7.5% (n=6) patients only (Table IV).

Table III: High Initial ETCP

<table>
<thead>
<tr>
<th></th>
<th>Mildly High ETCP</th>
<th>Moderately High ETCP</th>
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<tbody>
<tr>
<td>Range</td>
<td>26 - 40 cm H2O</td>
<td>41 - 60 cm H2O</td>
</tr>
<tr>
<td>% age</td>
<td>33.75% (n=27)</td>
<td>18.75% (n=15)</td>
</tr>
<tr>
<td>Male</td>
<td>0</td>
<td>2.5% (n=2)</td>
</tr>
<tr>
<td>Female</td>
<td>33.75% (n=27)</td>
<td>16.25% (n=13)</td>
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Table IV: ETCP after correction.

<table>
<thead>
<tr>
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<th>Initially Normal ETCP</th>
<th>ETCP Normal After Correction</th>
<th>ETCP Total</th>
<th>ETCP Mildly High after correction 28-37 cm H2O</th>
<th>H2O (mean = 32.5 cm H2O)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>47.5% (n=38)</td>
<td>45% (n=36)</td>
<td>92.5% (n=74)</td>
<td>7.5% (n=6)</td>
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All other patients now had leak proof ventilation with the ETCP of 25 cm H2O or less. To achieve the leak proof ventilation in these 6 patients, some extra air (0.5 to 1 ml) was injected into the ETT cuff. The new ETCP was measured in these 6 patients, which ranged between 28 to 37 cm H2O (mean = 32.5 cm H2O). In those patients who had an initial normal ETCP, 28% (35%) had a ETCP of 20 cm H2O or less; while 10% (12.5%) had a ETCP between 21 to 25 cm H2O (Table V).

Table V: Break up of Normal ETCP

<table>
<thead>
<tr>
<th>Range</th>
<th>% No. of patients</th>
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<tbody>
<tr>
<td>8-25 cm H2O(mean = 17.4 cm H2O)</td>
<td>47.5% (n = 38)</td>
</tr>
<tr>
<td>≤26 cm H2O</td>
<td>35% (n = 28)</td>
</tr>
<tr>
<td>21-25 cm H2O</td>
<td>12.5% (n = 10)</td>
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Discussion:
Anaesthesiologists, all over the world, have become careful to prevent various anaesthetic complications, since the pioneering study of Lunn and Mushin in 1982. Some of the tracheal and laryngeal complications can arise from the cuff of ETT.

Complications associated with ETT cuff.
1. Sore throat (incidence 6 to 90% of intubations). Mandal has shown that by limiting the ETCP, incidence of sore throat decreases.
2. Hoarseness (4-67% of intubations). Jones, Catling and Evans have shown that incidence of hoarseness can be decreased by using low pressure cuffs, smaller size ETT and lignocaine.
3. Laryngeal edema can occur along the path of ETT and along its cuff. It can be minimised by preventing high cuff pressures.
4. Ulcerations usually occur in posterior parts of larynx, and anterolateral aspects of trachea where the ETT cuff impinges.
5. Granuloma can occur on vocal cords, glottic and subglottic areas as a sequelae of ulcerations.
6. Vocal cord paralysis or paresis may result from high cuff pressure pressing the branches of recurrent laryngeal nerve.
7. Tracheal stenosis is reported following the use of high pressure cuff ETT.
8. Obstruction of trachea. Masselache reported obstruction of trachea on extubation after only 05 days use of a low pressure cuff ETT. The ischaemic necrosis of tracheal wall (from the cuff) lead to its weakening and collapse.

Endotracheal tube cuff pressure (ETCP) of more than 25 cm H2O can cause ischaemic damage to the mucosa and the wall of trachea. Patients whose tracheal mucosa and wall is already unhealthy, are at a higher risk of developing tracheal complications from ETT and its cuff.

Presence of respiratory infection, inhalational burn injury, hypotension, chronic corticosteroides administration, diabetes mellitus, simultaneous presence of nasogastric tube, advanced age and congenital abnormality of trachea, all make these patients prone to develop tracheal complications. Persistent ischaemia of tracheal mucosa cause may damage, which in extreme...
cases manifests as a destruction of cartilaginous tracheal rings. High pressure cuffs tend to inflate asymmetrically, deforming the trachea and ultimately producing tracheal dilatation. It seals the trachea at a high ETCP, a large part of which is transmitted to the tracheal wall. Low pressure cuffs inflate symmetrically, adopting the contour of the tracheal wall and produce a seal with low ETCP.

The cilia underlying the tracheal cuff can get damaged within two hours even if the ETCP is less than 25 cm H2O.

It is satisfying that nowadays, high volume low pressure (HVLP) tracheal tubes are commonly used.

However, the use of HVLP tubes, alone does not guarantee that a high ETCP could not develop. Once the HVLP cuff forms a tracheal seal, further addition of air can cause steep rise in ETCP, which is transmitted to the trachea and ischemic pressure injury may occur.

ETCP can be at a safe level in the beginning, but it can rise to high and unsafe levels with the passage of time. Alternatively ETCP may fall also.

It is suggested that during all long operations and in the intensive care patients ETCP be monitored regularly by using pressure gauge like the one we used (Portex) or others like Endotest by Rusch or Cuffmate by Mallinckrodt 

However, whenever the ETT is inflated with normal saline then a water column manometer can be used.

In the present study, 47.5% (n=38) patients had ETCP within the safe level of 25 cm H2O, while in 52.5% (n=42) patients, the ETCP was in unsafe levels.

When the ETCP was brought down to 25 cm H2O another 45% patients (n=36, 45%) had leak proof ventilation. This clearly showed that in 45% of patients the ETCP was unnecessary and in unsafe levels. This could have harmed the patients tracheal mucosa and wall. The attendant anaesthetist and the anaesthesia technician could have prevented this by correct inflation of the tube cuff and by measuring the ETCP.

However, only 7.5% (n=6) patients developed audible leak around the ETT and reduction in expired tidal volume, when ETCP was brought down to 25 cm H2O. This was corrected by addition of only 0.5 to 1 ml of air into the cuff. After acquiring the leak proof ventilation in these 6 patients the ETCP was recorded to be between 28 to 37 cm H2O (mean 32.5 cm H2O). This was only a mildly high ETCP. O’ Donnell 

McKenzie and Shin 

References:


