

RESPIRATION AND THE AIRWAY

Major complications during anaesthesia for elective laryngeal surgery in the UK: a national survey of the use of high-pressure source ventilation

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Background. Anaesthesia for laryngeal surgery may be complex and associated with complications.

Methods. We conducted a national survey exploring airway management and ventilation during elective laryngeal surgery, focusing primarily on injector and jet ventilation (i.e. high-pressure source ventilation: HPSV).

Results. Responses were received from 229 centres (75%). Several hospitals reported major complications during HPSV in the previous 5 yr, including three deaths. Complications during manual techniques led to seven discharge delays, three critical care admissions and three deaths. During the use of a high-frequency jet ventilation (HFJV), complications led to one discharge delay, two critical care admissions and no deaths. Complications were evenly spread between supraglottic, subglottic and transtracheal techniques. All deaths occurred in departments without HFJV. Three centres perform more than 100 transtracheal jet ventilation cases per year. None of these hospitals reported serious complications. Respondents in hospitals reporting serious complications were more likely to have plans to change practice ($P=0.03$). Elective laryngeal surgery is performed in 62% hospitals, of which 67% use HPSV. Supraglottic, subglottic and transtracheal techniques are used by 86, 50 and 35%, respectively. Manual ventilation devices are used widely. Only 17% of those using HPSV use an HFJV. Two-thirds of respondents initiate manual ventilation with pressures above 2 atm and only 6% start at ≤ 1 atm. I.V. cannulae are used for direct tracheal access by 18% and subcricoid insertion by 9%.

Conclusions. HPSV may cause serious complications and there are wide variations in clinical practice. This is an area where guideline development and examination of outcome data are warranted.

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Laryngeal surgery presents a challenge to the anaesthetist, as the upper airway is not only shared with the surgeon but also operated on by the surgeon. Surgery may improve an airway that was compromised before surgery, or may create new problems in a normal or compromised airway. Multiple methods of management of varying degrees of invasiveness are available, but their relative efficacy and safety are not clearly established. Several methods use 'jet' or 'injector' ventilation, more accurately termed 'high-pressure source ventilation' (HPSV).

We performed a national survey of anaesthetic management of laryngeal surgery, focusing on airway and ventilation management. In particular, we sought to determine variation in practice in the use of HPSV. We sought to acquire information on important complications arising

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as a result of the more invasive practices used and determined the current UK practice and explored limitations of this practice.

Methods

Our research ethics committee has previously stated that surveys of practice such as this do not need to be approved by them. A postal questionnaire (Appendix 1) was sent to all college tutors in the UK in July 2006. The tutor was asked to pass the questionnaire to a colleague with a major otorhinolaryngeal anaesthetic commitment, particularly if they anaesthetized regularly for laryngeal surgery. Questions were framed to determine departmental rather than personal practice. The questionnaire was re-sent to those who had not replied in September 2006. Microsoft Excel was used to aid data analysis.

Results

Two hundred and twenty-nine of 305 questionnaires sent were returned: a response rate of 75%. Eighty-seven (38%) returns indicated that their hospital does not perform elective laryngeal surgery: no further questions were asked. Further percentages relate to those 142 (62%) respondents who indicated that elective laryngeal surgery is performed in their hospital. Not all respondents answered all questions. Throughout this section, the percentages relate to the percentage of respondents who use certain techniques. This should not be confused with the percentage of laryngeal surgery undertaken with these techniques. Several respondents used more than one technique. We report first the data on complications.

Complications and plans for change

Complications

Respondents were asked to record known complications that had occurred during elective manual injector ventilation or a high-frequency jet ventilator (HFJV) in the previous 5 yr (Tables 1 and 2). A total of 65 complications, in 36 patients, had occurred during manual injector use in the previous 5 yr. These had led to seven delays in discharge, three admissions to critical care areas and three deaths. A total of 12 complications, in 9 patients, had occurred during the HFJV use in the previous 5 yr. These had led to one delay in discharge, two admissions to critical care areas and no deaths. Complications leading to critical care admission or death are described individually in Table 3.

Complications were evenly spread between supraglottic 23 (35%), subglottic 19 (30%) and transtracheal 23 (35%) techniques. Of the complications requiring critical care admission, one was during subglottic and two during transtracheal techniques. Of the deaths, one occurred during supraglottic ventilation and complications included

pneumothorax, pneumomediastinum and surgical emphysema. The second occurred during subglottic ventilation and complications included pneumothorax and surgical emphysema. The final death was during transtracheal jet ventilation (TTJV) and was associated with hypoxia. All the deaths occurred in departments that did not use HFJV. Complications requiring high-dependency unit (HDU) admission occurred in one centre which used HFJV only, one which used HFJV and Manujet injection and one which used Manujet ventilation only.

Of the complications during HFJV, complications were also evenly spread between supraglottic (4, 33%), subglottic (4, 33%) and transtracheal techniques (4, 33%). Of the complications requiring critical care admission, one was during a subglottic and one during a transtracheal technique. Both occurred in departments that used both HFJV and Manujet injector ventilation.

Three departments perform more than 100 cases per year of TTJV and these centres reported a total of 4 complications, with none leading to death, critical care admissions or delayed discharge.

Plans for change

The questionnaire asked whether the respondents planned to change any aspects of their management of such cases in the future.

Respondents from 32 departments who had classified the severity of reported complications answered this question: eight planned to change practice. These eight included all respondents who reported a death and two who reported complications leading to admission to critical care. The presence of a serious complication (i.e. leading to critical care admission or death) was more frequent in departments who planned to change practice than those who did not (5 out of 8 compared with 2 out of 24) and those departments who had a serious complication were more likely to plan to change practice than those who had had only a lesser complication (either clinically unimportant or only delaying discharge) (5 out of 7 compared with 3 out of 25).

Of eight respondents who stated they planned to change practice, seven stated what these changes were. Planned changes were as follows: where a death had occurred, 'technique no longer used', 'abandoned Sanders for Manujet', 'stopped TTJV since death'; where critical care admission occurred, 'tightening up training'; where only minor complications had occurred, all three were planning introduction of HFJV.

Techniques used by respondents

For elective laryngeal surgery, 98% of departments (137/140) make use of microlaryngeal tubes, 83% (116/140) make use of laser-resistant tracheal tubes and 67% (97/140) use a form of injector or jet ventilation (i.e. HPSV).

Only those 97 respondents who used HPSV were asked to answer subsequent questions, but not all replied: where

Table 1 Complications associated with elective use of manual injector ventilation in the respondent's department in the past 5 yr. *All hypercapnia

	Not stated	Clinically unimportant	Delayed discharge	HDU admission	Death	Sum
Pneumothorax	2	3	5	3	2	15
Surgical emphysema	1	8	4	2	2	17
Pneumomediastinum	2	1	1	0	1	5
Difficulty ventilating	2	6	3	0	0	11
Hypoxia	1	7	5	0	1	14
Other	0	3*	0	0	0	3
Supraglottic	1	8	4	0	1	14
Subglottic	0	3	2	1	1	7
Transtracheal	1	6	2	2	1	12
Not stated	1	2	0	0	0	3
Number of cases	3	19	8	3	3	36

Table 2 Complications associated with elective use of HFJV in the respondent's department in the past 5 yr. *Dental damage

	Not stated	Clinically unimportant	Delayed discharge	HDU admission	Death	Sum
Pneumothorax	0	0	1	2	0	3
Surgical emphysema	0	1	1	0	0	2
Pneumomediastinum	0	0	0	1	0	1
Difficulty ventilating	1	2	0	0	0	3
Hypoxia	0	2	0	0	0	2
Other	0	1*	0	0	0	1
Supraglottic	1	1	0	0	0	2
Subglottic	0	1	1	1	0	3
Transtracheal	0	3	0	1	0	4
Not stated	0	0	0	0	0	0
Number of cases	1	5	1	2	0	9

Table 3 Complications associated HDU/ICU admission or death. 'Supra', 'sub' and 'TTJV' refer to the site of ventilation: supraglottic, subglottic and transtracheal, respectively. *The respondents did not give any details of the cause of HDU admission in this case

	Ventilation	Site	Surgical emphysema	Pneumothorax	Pneumomediastinum	Failure to ventilate	Hypoxia
Death 1	Manual	Supra	Yes	Yes	Yes	—	—
Death 2	Manual	Sub	Yes	Yes	—	—	—
Death 3	Manual	TTJV	—	—	—	—	Yes
HDU admission 1	Manual	TTJV	Yes	Yes	—	—	—
HDU admission 2	Manual	TTJV	Yes	Yes	—	—	—
HDU admission 3	Manual	Sub	—	Yes	—	—	—
HDU admission 4	HFJV	Sub	—	—	Yes	—	—
HDU admission 5*	HFJV	TTJV	—	—	—	—	—

fewer than 97 replied, the number replying is stated and used for calculating percentages. Again, several respondents used more than one technique.

Techniques used for HPSV were supraglottic (via the surgeon's laryngoscope) by 86% (83/96), subglottic (via a small catheter placed through vocal cords, not a microlaryngeal tube) by 50% (48/96) and transtracheal ventilation (via a cannula placed percutaneously into the trachea) by 35% (34/96). Two respondents (2%) used apnoeic techniques (brief periods of surgery with no ventilation). Three (3%) used spontaneous ventilation during laryngeal surgery.

Devices used for elective injector/jet ventilation were Sanders-type injector 61% (57/93), Manujet (VBM GmbH, Sulz, Germany) 44% (41/93) and HFJV 17% (16/93). Forty-four per cent (41/93) only used a Sanders-type injector, 27% (25/93) only a Manujet and 7% (7/93)

only HFJV. Of those using HFJV, 94% (15/16) used an automated HFJV equipped with airway pressure monitoring and automatic gas cut-off.

When using manual injector ventilation (Sanders-type and Manujet), the initial driving pressure used would be 4 atm by 49% (38/78) of respondents, 2–4 atm by 19% (15/78), 1–2 atm by 21% (16/78), 0.5–1 atm by 5% (4/78) and <0.5 atm by 1% (1/78). Four respondents (5%) indicated they would use a variety of initial driving pressures.

For transtracheal injector/jet ventilation, respondents would use the following cannula: Ravussin cannula (VBM) 59% (20/34), other dedicated cricothyroidotomy cannula 26% (9/34) and a standard i.v. cannula 18% (6/34). The size of i.v. cannula was 14 gauge in 2 cases, 16 gauge in 1 and not stated in 3 cases.

Transtracheal access was inserted at the following levels: cricothyroid 88% (30/34), one ring below

cricothyroid 6% (2/34), two rings below cricothyroid 3% (1/34), all of these levels 3% (1/34).

Of the 34 respondents who use transtracheal techniques, the frequency of use per year was less than 5 times per year 44% (15/34), 5–10 times 29% (10/34), 10–50 times 18% (6/34) and >100 times 9% (3/34). Assuming that each of these respondents performs the median number indicated in their responses and those replying >100 perform only 100 then these three centres will perform more than half of such procedures in the UK.

Anaesthetic techniques used for laryngeal surgery included volatile-based anaesthesia in 20% and i.v.-based anaesthesia in 100%. Neuromuscular blocking agents were routinely used by 94% (83/89) and opioids were universally used. Results are not reported in detail.

Comments

Comments were encouraged and were made by 18 respondents. Excluding planned changes (discussed earlier), these are classified as follows:

- comments on increasing use of or safety of subglottic catheters (five respondents);
- statement on better safety of HFJV (two);
- statement that finances prevented purchase of HFJV (three);
- guidelines under development (one);
- TTJV routinely used for tumour surgery (one);
- other description of individual technique (six).

Discussion

The survey was replied by three quarters of respondents and is likely to represent current practice.

We believe the survey has demonstrated several important findings.

Of greatest interest is that this survey has identified serious morbidity and three deaths occurring in the past 5 yr as a result of the use of HPSV during elective laryngeal surgery. A survey is a poor method of detecting accurate figures of such complications but this methodology is unlikely to overestimate their number: more likely, through incomplete response, incomplete knowledge of respondents and partial (conservative) reporting, the number of events will be an underestimate. It is also likely that some details of cases may be lost when requesting that an individual reports complications in a department for the last 5 yr. So we suggest the data derived from this survey are likely to represent a minimum of complications. As the survey was restricted to elective surgery, the figure does not include emergencies. It is notable that most serious complications, and all deaths, occurred during the use of manual ventilation techniques. Automatic ventilators often feature a pressure monitor/alarm and automatically cut off ventilation when peak or pause airway pressure is raised.

Use of such devices has the potential to either prevent or mitigate the impact of pressure-related injuries. Such equipment is widely available on the continent but used only by a small minority of centres responding to this audit: only 7% use HFJV exclusively. Robust reports of serious morbidity are difficult to find in the UK practice. A database collecting such data would be a useful learning resource: the 4th National Audit Project of the Royal College of Anaesthetists will set out to do this for a period of 1 yr and is a useful starting point. Analysis and reporting of relevant data from such sources as the National Reporting and Learning System (NRLS) and the National Health Service Litigation Authority (NHSLA) would also be welcome.

Practice in centres where major complications occurred did not markedly differ from practice in other centres. However, those centres where a major complication had occurred in the last 5 yr were more likely to plan a change in practice than those where none or more minor complications had occurred. This might be interpreted as suggesting that only a major complication leads to revision of practice. Comments suggest that many centres consider HFJV a safer technique than manual techniques but cost pressures prevent its introduction. This is concerning.

We are not aware of the UK or European guidelines for best practice in the management of laryngeal surgery in general or in HPSV. The European Society of Jet Ventilation does not publish such guidance and its president is not aware of any guidelines (Ihra, personal communication). In the absence of such evidence-based or consensus guidelines, it is not appropriate for us to state what is good or bad practice, but some comments based on published literature are possible. Areas which are potentially controversial or where conservative practice might lessen complications can be identified. These include lack of HFJV and pressure-limited equipment, use of unnecessarily high initial driving pressures for manual ventilation, use of cannulae for TTJV not designed for such use.

This is an area where robust data are difficult to find and expert opinion is often the only source of reference. In recent publications from centres of experience and expertise, the following statements have been made: to 'caution against use of TTJV when ventilation from supraglottic or subglottic catheters can be used, as risk of iatrogenic injury is too high'¹ and 'strongly advocate the use of HFJV for reasons of safety'.^{2,3} In contrast, others report almost routine use of TTJV with the technique used for almost 2% of patients who require tracheal intubation.⁴ Use of fiberoptic guidance to confirm anatomical position before initiating TTJV has also been described and self-reported as 'good practice'.⁵ This practice highlighted potential problems with the technique (15% first attempt failure, increased tracheal compression and 2% posterior tracheal wall damage when a cannula is placed lower than the cricothyroid membrane). The use of fiberoptic

guidance reduced poor placement from more than 1 in 3 to less than 1 in 5. It is notable that fiberoptic confirmation of tracheal puncture site, during percutaneous tracheostomy on intensive care, is a standard practice.⁶ Other case series report an increase in complications when multiple attempts or anatomically low approaches are made and in patients who have cancer, have had radiotherapy and when inexperienced operators perform the procedure.^{2,5}

In our hospital, we have based our local guidelines on the earlier-mentioned evidence. These guidelines are shown in Appendix 2. We would be interested in comments on these.

It is also notable that only 42% of departments that replied perform elective surgery with HPSV and of these, only 35% of departments currently use TTJV. This would suggest that two-thirds of departments are not able to teach this technique routinely on patients. Placement of a cricothyroid cannula and ventilation through it is one of the main methods advocated for the rescue of the airway in a 'can't intubate, can't ventilate' (CICV) situation and is included in the Difficult Airway Society guidelines for the management of such an event.⁷ There is considerable confusion on how such procedures should be performed, both in terms of equipment use² and ventilation strategies after cannula placement.^{8,9} Performance of percutaneous tracheostomy on the intensive care unit may offer anaesthetists opportunity to practice direct access to the trachea.¹⁰ However, this technique has dissimilarities to cricothyroidotomy and provides no training in this mode of ventilation. We believe this has implications for training.

The wide variety of techniques used reflects the lack of evidence of the best route of airway access (supraglottic, subglottic or transtracheal). Of note, supraglottic techniques require the airway to be established and optimized by the surgeon. This necessitates an interruption in airway maintenance while responsibility is handed to the surgeon. The quality of ventilation is dependent on the ability of the surgeon to align the 'jet' with the airway.¹¹ Surgical priorities, in terms of accessing the operative site, may on occasion lead to poor alignment and interruption of effective ventilation. Subglottic ventilation and transtracheal ventilation, in which a catheter is placed within the trachea, are theoretically more prone to pressure-related complications, as application of a high-pressure inspiration can occur despite the expiratory route being blocked. This is logically, less likely to occur during supraglottic techniques, as the ventilating jet is outside the trachea, so expiratory obstruction is likely to coincide with inspiratory obstruction. Subglottic techniques with small 2–3 mm external diameter catheters are becoming increasingly available and appear to be the technique of choice in some centres. Transtracheal techniques have the potential problems of both invasive access to the trachea (with the potential for misplacement and adjuvant injury) and ventilation from within the trachea. The main advantage of transtracheal techniques is that it provides the surgeon with operating conditions unhindered by anaesthetic

equipment or the need for the surgeon to maintain ventilation. In this survey, supraglottic techniques were used by almost 90% of those using HPSV, subglottic techniques by 50% and transtracheal ventilation by 35%. Reported complications were evenly spread between supraglottic, subglottic and transtracheal techniques.

The most commonly used high-pressure source ventilator was a Sanders-type injector, used by almost two-thirds. This device applies a fixed pressure of 4 atm. The Manujet, which provides a more controlled pressure (0–4 atm), was used by almost half of respondents and an automated HFJV, by one in six. Many respondents used a variety of devices. Where only one device type was used, it was six times more likely to be a Sanders-type injector than an HFJV.

Manual jet ventilation may be initiated with the patient awake if low driving pressures are used. This allows confirmation of correct placement of the ventilatory device and will minimize the impact of misplaced devices (particularly transtracheal cannulae). In this survey, only 6% start manual injector ventilation at 1 atm pressure or lower, only 27% 2 atm or lower and half start at maximum pressure (4 atm). Application of such a high initial driving pressure is potentially dangerous.

The study has limitations. Most important is that we did not gather data on the exact context and nature of the complications reported. For instance, if a respondent reported airway obstruction as a complication, we do not know how long that lasted, nor were terms such as 'hypoxia' defined. Also if a respondent reported a case of barotrauma and hypoxia, we do not know whether these were independent of each other or whether the barotrauma caused hypoxia. However, we do broadly know the outcome of the reported complications, as these were classified according to increasingly severe outcome. The design of a postal survey makes exploration in greater depth difficult and patient confidentiality issues limit the extent that details can be legally reported in such a manner. A second limitation is that when a centre reported more than one case of complications, the questionnaire did not allow us to determine which combination of complications were associated with each case. However, no hospital reporting complications with serious outcomes reported more than one case in total, so we were able to state the combinations for each of these patients. A further limitation is that we have focused on elective HPSV and have not sought data on other techniques used for laryngeal surgery. Although this may be viewed as a limitation of this survey, it was always the intention to focus mainly on HPSV techniques. Finally, the absence of denominator data means that we cannot determine relative incidences of complications overall or with different techniques. This is beyond the scope of a simple survey.

In summary, we have performed a national survey of anaesthetic management of elective laryngeal surgery focusing on the use of HPSV techniques. A significant

minority of departments use techniques using HPSV. The use of manual techniques is considerably more common than the use of dedicated mechanical HFJVs with pressure monitoring. The survey has identified evidence that serious morbidity and mortality occur with these techniques and that these occur more frequently with manual techniques. Guidelines for such techniques would be welcome.

Funding

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Appendix 1. Questionnaire

National survey on anaesthetic techniques for elective laryngeal surgery

Please answer the following questions regarding practice in your department.

- (1) Does your department provide anaesthesia for **elective** laryngeal surgery? Yes/No
IF 'no' please stop now and return form in the s.a.e. provided.
- (2) Which of the following are used in the department for elective laryngeal surgery?
 - (i) Microlaryngeal tubes Yes/No
 - (ii) Laser tubes Yes/No
 - (iii) Jet ventilation (i.e. Sanders type or high frequency jet ventilation) Yes/No
IF 'no' to 2 (iii) please stop now and return form in the s.a.e. provided
- (3) Which of the following ventilation techniques are used in your department?
 - (i) Supraglottic jet ventilation (via the surgeon's laryngoscope) Yes/No
 - (ii) Subglottic jet ventilation (via a small catheter placed through vocal cords [not a microlaryngeal tube]) Yes/No
 - (iii) Transtracheal jet cannula (via percutaneous tracheal cannula) Yes/No
 - (iv) Apnoeic techniques (brief periods of surgery with no ventilation) Yes/No
 - (v) Other (please specify)
- (4) For elective 'jet ventilation' what 'ventilator' does your department use?
Sanders type injector/Manujet/High frequency jet ventilator (HFJV)
- (5) For elective manual jet ventilation what driving pressure is **initially** used?
 - (i) 4 bar (i.e. direct pressure from anaesthetic machine) or
- 2–3.99 bar/ 1–1.99 bar/ 0.5–0.99 bar/ other.
- (6) If using transtracheal jet ventilation what cannula is used?
 - (i) Standard i.v. cannula 20G/18G/16G/14G Yes/No
 - (ii) Ravussin catheter Yes/No
 - (iii) Other dedicated cricothyroidotomy cannula Yes/No
- (7) At which level? Cricothyroid/1 space lower/2 spaces lower/>2 spaces lower
- (8) How often is TTJV used? <5 times per year/5–10 times/10–50 times/>100 times
- (9) Which anaesthetic technique is most commonly used for laryngeal surgery requiring jet ventilation in your department? (more than one answer is likely)
 - (i) Volatile-based anaesthetic
 - i. Which agent? isoflurane/sevoflurane/desflurane/other.
 - (ii) Intravenous agent based anaesthetic
 - i. Which agent? propofol/thiopentone/etomidate/ketamine/other.
 - (iii) Is a muscle relaxant routinely used
 - i. Which one? suxamethonium/mivacurium/acracturium/vecuronium/other
 - (iv) Is an opioid routinely used
 - i. Which one? remifentanyl/alfentanil/fentanyl/other.
- (10) If your department has an automated High Frequency Jet Ventilator, is it equipped with an automatic cut off when increased pressure is detected? Yes/No
- (11) Are you aware of any complications associated with **elective** use of **manual** jet ventilation in your department in the past five years?

Pneumothorax	Yes/No
Surgical Emphysema	Yes/No
Pneumomediastinum	Yes/No
Failure to ventilate	Yes/No
Hypoxaemia	Yes /No
Other (please specify)	
Technique being used	supraglottic/subglottic/transtracheal
Please indicate severity of events	
Clinically unimportant/Delayed patient discharge/Required HDU or ICU admission/Contributed to death or permanent disability/Caused death or permanent disability	
- (12) Are you aware of any complications associated with **elective** use of automated jet ventilation in your department in the past five years?

Pneumothorax	Yes/No
Surgical Emphysema	Yes/No
Pneumomediastinum	Yes/No
Failure to ventilate	Yes/No
Hypoxaemia	Yes /No
Other (please specify)	

Technique being used supraglottic/subglottic/ transtracheal

Please indicate severity of events

Clinically unimportant/Delayed patient discharge/ Required HDU or ICU admission/Contributed to death or permanent disability/Caused death or permanent disability

- (13) Does your department plan to change any aspects of your management of such cases in the future? Yes/No
If so how?
- (14) Any further comments

Appendix 2

Transtracheal Jet Ventilation Guidelines (elective cases)

TTJV is a rarely performed technique with the potential for frequent and serious complications. TTJV is only rarely needed and where possible the technique should be avoided. That being said these guidelines represent suggested 'best practice'.

- TTJV is not to be performed by junior anaesthetists alone without specific consultant approval.
- TTJV should not to be done by a solo anaesthetist unless performed before.
- Where possible it is strongly recommended to use fiberoptic guidance/confirmation of catheter position prior to TTJV.
- Clinically confirm position of the cannula before jetting (aspiration of air and capnography +/- fiberoptic examination)
- If in doubt do not jet!
- Consider performing one inspiration before the patient is asleep, to confirm correct positioning. This should be done at a low volume and a low pressure (0.5 bar) timed to synchronise with patient inspiration (tell the patient).
- Once the patient is anaesthetised ensure neuromuscular blockade is maintained to prevent cord closure and airway obstruction.
- Slowly increase driving pressure: you should rarely need >2.5 bar and if this is needed have an increased level of suspicion of complications.
- Actively observe and palpate for exhalation for each breath.
- Maintain a patent upper airway at all times that the surgeon is not performing laryngoscopy (i.e. use jaw thrust, Guedel or laryngeal mask airway as needed)
- Observe for subcutaneous emphysema throughout: preferably keep patient as free from drapes as possible.
- If emphysema occurs inform surgeon and stop (see below: actively seek complications and treat).
- Beware: obstructive lesions, cancer, previous radiotherapy, multiple insertions, use of surgical laser. All are associated with an increase in the incidence of barotrauma.

If problems occur.

- Stop TTJV
- Consider insufflation with oxygen. . . 2-4 litre min⁻¹
- Assume upper airway obstruction and relieve by Guedel, LMA or intubation
- If problems persist consider conversion to large cricothyroid cannula (i.e. surgical airway or Melker device) allowing conventional ventilation.

A postoperative CXR (looking for pneumothorax and pneumomediastinum) should be performed if there is any subcutaneous emphysema during or after TTJV.

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