Anaesthesia 2014, 69, 1388–1396 doi:10.1111/anae.12788

# Review Article

## The efficacy of lidocaine to prevent laryngospasm in children: a systematic review and meta-analysis*

**T. Mihara,[1] K. Uchimoto,[2] S. Morita[3] and T. Goto[4]**

*1 Staff Anaesthesiologist, Department of Anaesthesiology, Kanagawa Children's Medical Centre, Yokohama, Japan*
*2 Assistant Professor, 4 Professor and Chair, Department of Anaesthesiology and Critical Care Medicine, Yokohama City University Graduate School of Medicine, Yokohama, Japan*
*3 Professor, Department of Biomedical Statistics and Bioinformatics, Kyoto University Graduate School of Medicine, Kyoto, Japan*

### Summary

The purpose of this meta-analysis was to determine the efficacy of lidocaine in preventing laryngospasm during general anaesthesia in children. An electronic search of six databases was conducted. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines were adhered to. We included randomised controlled trials reporting the effects of intravenous and/or topical lidocaine on the incidence of laryngospasm during general anaesthesia. Nine studies including 787 patients were analysed. The combined results demonstrated that lidocaine is effective in preventing laryngospasm (risk ratio (RR) 0.39, 95% CI 0.24–0.66; $I^2 = 0$). Subgroup analysis revealed that both intravenous lidocaine (RR 0.34, 95% CI 0.14–0.82) and topical lidocaine (RR 0.42, 95% CI 0.22–0.80) lidocaine are effective in preventing laryngospasm. The results were not affected by studies with a high risk of bias. We conclude that, both topical and intravenous lidocaine are effective for preventing laryngospasm in children.

*Correspondence to: T. Mihara*
*Email: miharaxxxtotoro@yahoo.co.jp*
**Presented in part at the European Society of Anaesthesiology Congress, Stockholm, Sweden, May/June 2014.*
*Accepted: 28 May 2014*

### Introduction

Laryngospasm is a serious complication of general anaesthesia that is known to occur most often at induction of anaesthesia, during tracheal intubation and at extubation. The reported frequency of laryngospasm during general anaesthesia is between 1.7% and 25% in children [1–3]. Laryngospasm causes complete obstruction of the upper airway and can lead to oxygen desaturation, negative pressure pulmonary oedema and death [4], and its prevention during general anaesthesia is challenging. Lidocaine, administered either intravenously or topically, is often used to prevent laryngospasm in children during anaesthesia or immediately before tracheal extubation. However, studies have yielded conflicting results [5–8]. Most of the clinical studies are underpowered due to the relatively low incidence of laryngospasm during general anaesthesia. Moreover, the routes of administration (for example, intravenous or topical) have varied. We decided to analyse the efficacy of lidocaine in children and to identify the most effective route of administration. We therefore conducted a systematic review and

meta-analysis of randomised controlled trials (RCTs) that evaluated the effect of lidocaine in preventing laryngospasm during general anaesthesia.

## Methods

We followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement [9, 10].

We searched MEDLINE, the Cochrane Central Register of Controlled Trials (CENTRAL), Embase and Web of Science initially on 15 February 2013 and again on 4 April 2014. The reference lists of the full articles were also searched. We also conducted a search of clinicaltrials.gov and the UMIN clinical trials registry. We used the following search strategy combining free text and MeSH terms for searching PubMed: ("laryngismus"[MeSH Terms] OR "laryngismus"[All Fields] OR "laryngospasm"[All Fields] OR "laryngeal spasm"[All Fields] OR "laryngeal spasms"[All Fields] OR "emergence"[All Fields]) AND ("lidocaine"[MeSH Terms] OR "lidocaine"[All Fields] OR "lignocaine"[All Fields] OR "xylocaine"[All Fields]) AND ("controlled clinical trial"[pt] OR "randomized"[tiab] OR "placebo"[tiab] OR "drug therapy"[Subheading] OR "randomly"[tiab] OR "trial"[tiab] OR "groups"[tiab]) NOT ("animals"[MeSH Terms] NOT "humans"[MeSH Terms]. Two authors (TM and KU) independently assessed the suitability of all the studies that were identified for potential inclusion as a result of the search strategy. The full-text versions of potentially relevant studies chosen by at least one author were retrieved and evaluated and those that met the inclusion criteria were then assessed separately. Any discrepancies were resolved through discussion and if no agreement could be reached, a third author (TG) arbitrated.

All trials that compared lidocaine with a control (i.e. placebo or no treatment) and reported the incidence of laryngospasm were included in this study. We excluded studies in adults and studies that did not have adequate comparators. We excluded studies in which we could not confirm the incidence of laryngospasm because it was not clearly reported. We also excluded case reports, comments or letters to the editor, reviews and animal studies. Eligibility was not restricted by language, type of surgery or anaesthetic technique.

The primary outcome of the meta-analysis was evaluation of the effect of lidocaine, compared with a control, for prevention of laryngospasm during general anaesthesia in children. We conducted subgroup analysis according to the route of administration (i.e. intravenous or topical lidocaine).

A data collection sheet was created that included information on: (1) ASA physical status; (2) age; (3) type of surgery; (4) anaesthetic technique; (5) type of airway device; (6) route of administration of lidocaine; (7) dose of lidocaine; (8) timing of administration of lidocaine; (9) timing of assessment for laryngospasm; (10) type of control (i.e. placebo or no treatment); (11) primary outcomes of individual studies; number of patients in (12) lidocaine group and (13) control group; number of reported incidents of laryngospasm in (14) lidocaine group and (15) control group; and (16) adverse effects of lidocaine such as seizures, arrhythmias or allergic reactions. When laryngospasm was classified according to severity (e.g. mild, moderate or severe), we extracted the data from the severe category; we did not consider stridor or bronchospasm as laryngospasm. If laryngospasm was reported together with stridor or bronchospasm and we could not extract the data of laryngospasm separately, we contacted the lead author for more information. If we were unable to obtain more detailed data from the author, we extracted the mixed data, i.e. laryngospasm, stridor and bronchospasm. We conducted a sensitivity analysis to confirm whether the pooled results would change when the mixed data were excluded.

Two authors (TM and KU) independently extracted the data from the included studies and then cross-checked the data. Disagreements were resolved by discussion between the two authors. If no agreement could be reached, a third author (TG) arbitrated.

A translator was consulted for studies published in languages other than English or Japanese.

We assessed the risk of bias as described by the Cochrane Handbook for Systematic Reviews of Interventions [11]. We assessed the risk of bias in sequence generation, allocation sequence concealment, blinding of patients, blinding of healthcare providers, blinding of data collectors, blinding of outcome

 

assessors, incomplete outcome data, selective outcome reporting and other bias. We also summarised risk of bias. Because we determined that a lack of blinding of patients would be unlikely to affect the incidence of laryngospasm, we attributed a low risk of bias to all studies in this domain. Two authors (TM and KU) independently assessed risk of bias for each RCT. Disagreements were resolved by a third author (TG).

For evaluating the quality of evidence for the effect of lidocaine in preventing laryngospasm, we used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [12, 13], which specifies four levels: high; moderate; low; and very low.

Dichotomous data were summarised using risk ratio (RR) with a 95% CI. If the 95% CI included a value of 1, we considered the difference to be non-significant. The number needed to treat (NNT) was calculated to estimate the overall clinical impact of the intervention. Heterogeneity was quantified with the $I^2$ statistic. We used the random-effects model (Dersimonian and Laird method) to combine the results of the studies. Forest plots were used to represent and evaluate the effects of treatment graphically. Small study effects, including publication bias, were assessed using a contour-enhanced funnel plot and a Begg's rank correlation test [14] and was considered to be present at a p value $< 0.1$ in the asymmetry test. Subgroup analyses were performed according to the route of administration (intravenous or topical). Sensitivity analyses were performed by excluding studies with a high risk of bias; restricting to peer reviewed manuscripts; and excluding studies that reported mixed data for the occurrence of laryngospasm, stridor and bronchospasm. In addition, we conducted meta-regression analysis incorporating the following covariates: type of surgery (tonsillectomy vs others); airway device (tracheal tube vs supraglottic airway device); definition of 'laryngospasm' (mixed data vs others); route of administration (topical vs intravenous); and dose of lidocaine (low vs high). We defined an intravenous dose $> 1.5$ mg.kg$^{-1}$ or a topical dose of 4 mg.kg$^{-1}$ as 'high-dose'. Statistical analyses were performed using the R statistical software package version 2.13.0 (R Foundation for Statistical Computing, Vienna, Austria).

## Results

Our search of MEDLINE, the Cochrane Central Register of Controlled Trials (CENTRAL), Embase, Web of Science, clinicaltrials.gov and the UMIN clinical trial registry databases produced a total of 535 citations. The full texts of 49 articles [5–8, 15–59] were examined in detail. We included nine RCTs [5–7, 38, 44–48] with a total of 787 participants (Fig. 1). Of the included studies, eight were available in English [5–7, 38, 45–48] and one in Spanish [44]. Eight studies were presented as peer-reviewed papers [5–7, 44–48] and one as an unpublished abstract [38].

The details of all included studies are shown in Table 1. Lidocaine was administered intravenously in five studies [5–7, 38, 47] and topically in five studies [6, 44–46, 48]. Intravenous lidocaine was administered in doses between 1.0 and 2.0 mg.kg$^{-1}$ before tracheal extubation. In four of these studies, intravenous lidocaine was administered within 5 min of extubation [5–7, 47], while the timing of administration was described simply as 'before extubation' in another study [38].

Methods of topical lidocaine application included lidocaine spray on to the larynx [6], lidocaine spray to the supraglottic, glottic and subglottic areas [48], aerosol administration [44] or lidocaine jelly placed on the dorsal surface of the supraglottic airway device [45, 46]. Topical lidocaine was administered before induction in one study [44], before intubation in one study [6], at the time of intubation in one study [48] and during supraglottic airway device insertion in two studies [45, 46].

There were three studies that reported mixed data for laryngospasm, stridor and bronchospasm [6, 46, 48]. Adverse effects of lidocaine were not reported in these studies.

The combined results from nine studies that included 787 patients demonstrated a statistically significant reduction in the incidence of laryngospasm in patients who received lidocaine. In addition, subgroup analysis indicated that both intravenous and topical lidocaine have a statistically significant effect on reducing the incidence of laryngospasm (Fig. 2). The reported frequency of laryngospasm during general anaesthesia in children is between 1.7% and 25%

 

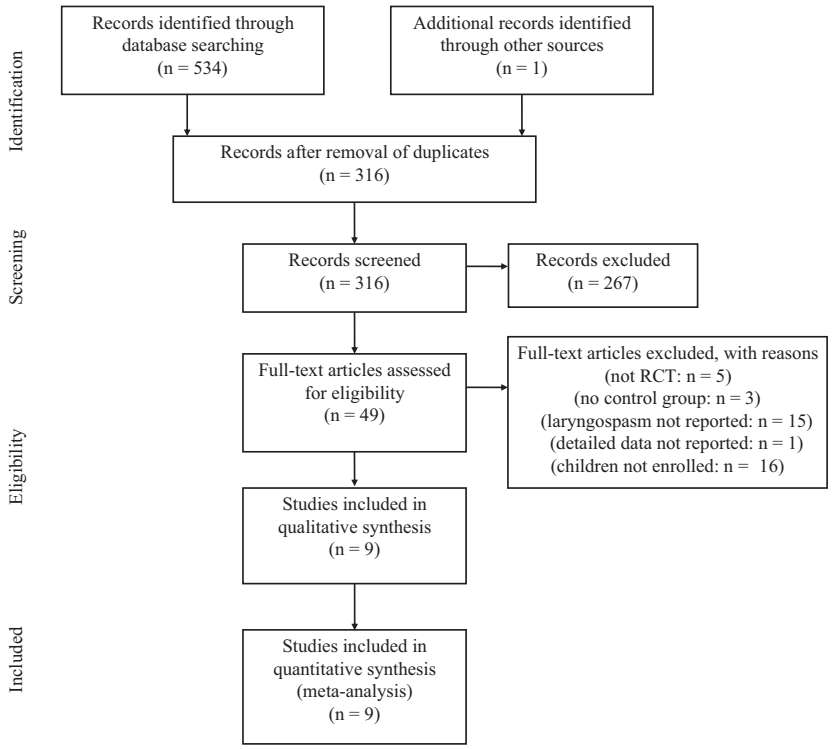


**Figure 1** PRISMA flow diagram showing the identification, screening, eligibility, and inclusion of studies on the effect of lidocaine in preventing laryngospasm in children. RCT, randomised controlled trial.

[1–3]. The number needed to treat (NNT) to prevent laryngospasm in children is between 7 (95% CI 5–12) and 96 (95% CI 77–173) when considering these baseline risks.

The results were not different when studies with a high risk of bias were excluded (RR 0.44, 95% CI, 0.24–0.82), when restricting data to peer-reviewed manuscripts (RR 0.41, 95% CI 0.24–0.69) or when studies reporting mixed data for laryngospasm were excluded RR (0.31, 95% CI 0.12–0.82). The results of meta-regression analysis indicated that none of these five covariates had a significant effect (Table 2). A low risk of bias was attributed to one study, and a high risk of bias was attributed to four studies (Table 3). All nine studies mentioned randomisation, but only two studies reported the details of randomisation and only one study reported details of the method of allocation concealment. Healthcare providers, data collectors and outcome assessors were adequately blinded in five, three and three studies, respectively.

According to the GRADE methodology, the quality of the evidence for the effect of lidocaine in preventing laryngospasm was downgraded to moderate because of a serious risk of bias.

Small study effects were assessed using contour-enhanced funnel plot (Fig. 3) and Begg's rank correlation test. The results of the asymmetry test were not statistically significant.

## Discussion

The results of our meta-analysis demonstrate that lidocaine is effective in preventing laryngospasm in children during general anaesthesia. Our sensitivity analyses have revealed that the effect of lidocaine in preventing laryngospasm in children is not affected by studies with a high risk of bias and/or non-peer-reviewed studies. The quality of evidence, according to the GRADE approach, was moderate. In addition, our subgroup analyses indicate that both intravenous and topical lidocaine are effective in preventing laryngospasm in children.

Our systematic review and meta-analysis reveal that the risk ratio (95% CI) of laryngospasm during general anaesthesia in children is 0.39 (0.24–0.66).

 

**Table 1** A summary of the included studies that assessed the effect of lidocaine in preventing laryngospasm in children.

| Source | ASA physical status | Age | Surgery | Anaesthetic technique | Type of airway device | Route of administration | Dose of lidocaine | Timing of administration | Control |
|---|---|---|---|---|---|---|---|---|---|
| Sanikop & Bhat 2010 [47] | 1, 2 | 3 months – 6 years | Cleft palate surgery | Ketamine and suxamethonium (induction), $N_2O$ and vecuronium (maintenance) | Tracheal tube | Intravenous | 1.5 $mg.kg^{-1}$ | 2 min before extubation | Placebo |
| Koç et al. 1998 [6] | Not mentioned | 5–10 years | Tonsillectomy and adenoidectomy | $N_2O$ and halothane | Tracheal tube | Intravenous | 1 $mg.kg^{-1}$ | 5 min before extubation | Placebo |
| Leicht et al. 1985 [7] | 1 | 3–7 years | Tonsillectomy | $N_2O$ and halothane (induction), $N_2O$ and halothane (maintenance) | Tracheal tube | Intravenous | 1.5 $mg.kg^{-1}$ | 4–5 min before extubation | Placebo |
| Bidwai et al. 1979 [38] | 1 | 2–8 years | Tonsillectomy and adenoidectomy | $N_2O$ and halothane | Tracheal tube | Intravenous | 1 $mg.kg^{-1}$ | Before extubation | Placebo |
| Baraka 1978 [5] | Not mentioned | 3–6 years | Tonsillectomy | Halothane (induction), halothane (maintenance) | Tracheal tube | Intravenous | 2 $mg.kg^{-1}$ | One minute before extubation | No treatment |
| Schebesta et al. 2010 [46] | 1, 2 | 1–10 years | Minor surgical procedures | Sevoflurane, fentanyl, and propofol (induction), fentanyl and sevoflurane (maintenance) | Supraglottic airway device (SAD) | Topical | 0.3 $ml.kg^{-1}$ of 2% lidocaine-containing gel | During insertion of SAD | Placebo |
| Penaloza et al. 1999 [44] | 1, 2 | 1–8 years | Not mentioned | Halothane | Tracheal tube | Topical | 10 mg | Before induction | Placebo |
| Koç et al. 1998 [6] | Not mentioned | 5–9 years | Tonsillectomy and adenoidectomy | $N_2O$ and halothane | Tracheal tube | Topical | 4 $mg.kg^{-1}$ | Before intubation | Placebo |
| O'Neill et al. 1994 [45] | Not mentioned | 4 months – 14 years | Not mentioned | $N_2O$ and halothane (induction), $N_2O$ and halothane or isoflurane (maintenance) | Supraglottic airway device | Topical | Approximately 1/4 teaspoon of 2% viscous lidocaine | During insertion of SAD | Placebo |
| Staffel et al. 1991 [48] | Not mentioned | 10 years | Tonsillectomy and/or adenoidectomy | Not mentioned | Tracheal tube | Topical | 4 $mg.kg^{-1}$ | At the time of intubation | No treatment |

$N_2O$, nitrous oxide.

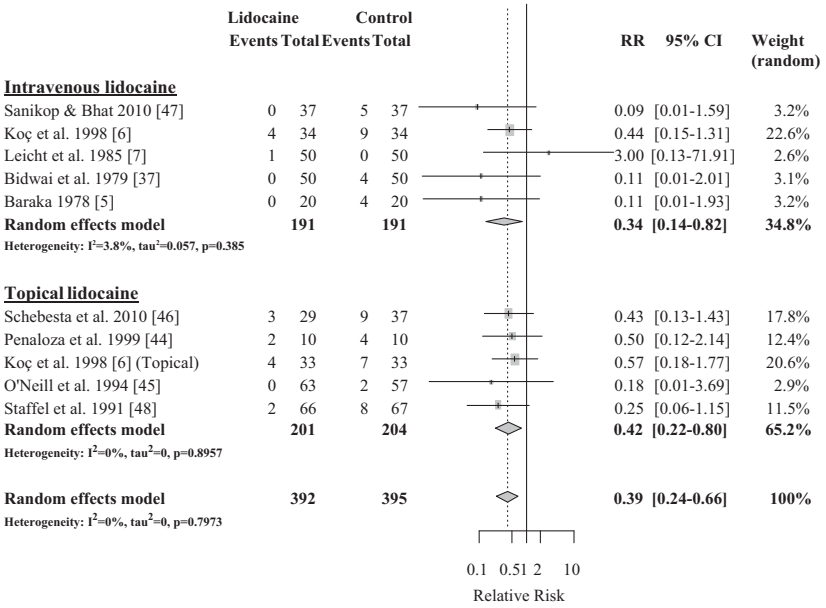


**Figure 2** Forest plot for subgroup analysis of the effect of lidocaine on preventing laryngospasm in children.

**Table 2** Results of a meta-regression analysis to determine whether covariates had a significant effect.

| | Relative change in risk ratio (95% CI) | p value |
|---|---|---|
| Type of surgery | 1.17 (0.09–15.0) | NS |
| Airway device | 1.43 (0.16–13.1) | NS |
| Definition of laryngospasm | 0.74 (0.12–4.37) | NS |
| Route of administration | 1.55 (0.31–7.75) | NS |
| Dose of lidocaine | 1.44 (0.31–6.74) | NS |

Most RCTs could not provide good estimates of the effect because the incidence of laryngospasm is low. Recently, however, Erb et al. conducted a crossover trial [60] to investigate the effect of intravenous lidocaine in preventing laryngospasm. In their study, laryngospasm was induced by spraying distilled water onto the larynx in children anaesthetised with sevoflurane and hence the incidence of laryngospasm was increased. Their study design allowed them to provide better estimates of the effect of lidocaine. They reported that the incidence of laryngospasm was reduced from 38% at baseline to 15% 2 min after 2 $mg.kg^{-1}$ intravenous lidocaine administration; the risk ratio was 0.4, which is almost identical to ours and, we believe, confirms that our results provide the best estimate thus far of the efficacy of lidocaine.

Our meta-analysis included four studies [5–7, 47] in which intravenous lidocaine was administered within 5 min of tracheal extubation and, in another study [38], the timing of administration was described as 'before extubation'. It has been reported [35] that coughing after extubation can be prevented by 2 $mg.kg^{-1}$ intravenous lidocaine administered within 5 min of tracheal extubation, but this effect was short-lived because the plasma concentration of lidocaine was only sufficiently high (> 3 $\mu g.ml^{-1}$) for 5 min after intravenous administration. In the crossover trial by Erb et al. [60], the incidence of laryngospasm 2 min following 2 $mg.kg^{-1}$ intravenous lidocaine administration was reduced significantly, while the effect was no longer significant at 10 min. The timing of intravenous administration of lidocaine appears to be important in its efficacy in preventing laryngospasm. In our meta-analysis, no study evaluating the effect of intravenous lidocaine administered > 5 min before extubation was included. Thus, we believe that prophylactic intravenous lidocaine for the prevention of laryngospasm should be administered within 5 min of tracheal extubation.

A recent upper respiratory tract infection (URTI) and [47] passive smoking are known to increase the risk of laryngospasm in children. Schebesta et al. [46]

 

**Table 3** Risk of bias in studies assessing the effect of lidocaine in preventing laryngospasm in children.

| Source | Sequence generation | Allocation concealment | Patients blinded | Healthcare providers blinded | Data collectors blinded | Outcome assessors blinded | Incomplete outcome data | Selective reporting | Other bias | Summary |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanikop & Bhat 2010 [47] | Low | Unclear | Low | Unclear | Unclear | Unclear | Unclear | Low | Low | Unclear |
| Koç et al. 1998 [6] (Intravenous) | Unclear | Unclear | Low | Low | Unclear | Unclear | Unclear | Low | Low | Unclear |
| Leicht et al. 1985 [7] | Unclear | Unclear | Low | Low | Low | Low | Unclear | Low | Low | Unclear |
| Bidwai et al. 1979 [38] | Unclear | Unclear | Low | Low | Low | Low | Unclear | Unclear | Unclear | Unclear |
| Baraka 1978 [5] | Unclear | Unclear | Low | High | High | High | Unclear | Unclear | Unclear | High |
| Schebesta et al. 2010 [46] | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Penaloza et al. 1999 [44] | Unclear | Unclear | Low | High | High | High | Unclear | Unclear | Unclear | High |
| Koç et al. 1998 [6] (Topical) | Unclear | Unclear | Low | Low | Unclear | Unclear | Unclear | Low | Low | Unclear |
| O'Neill et al. 1994 [45] | Unclear | Unclear | Low | High | High | High | Low | Low | Low | High |
| Staffel et al. 1991 [48] | High | High | Low | High | High | High | Unclear | Low | Low | High |

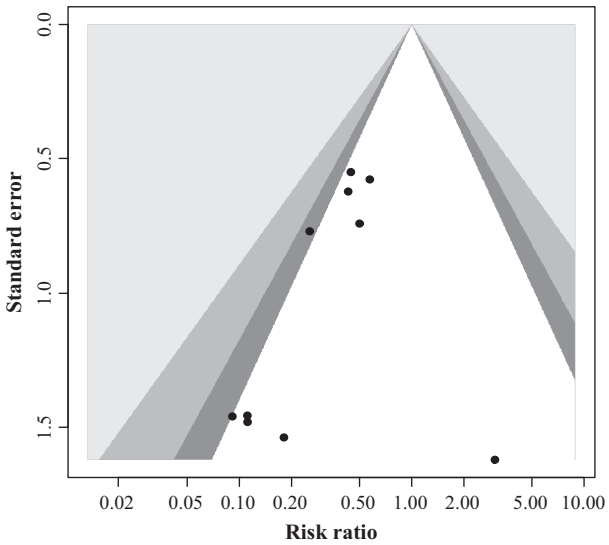


**Figure 3** Contour-enhanced funnel plot to assess small study effects of studies included in the meta-analysis. (■ $0.1 > p > 0.05$, ■ $0.05 > p > 0.01$, □ $p < 0.01$, • studies)

reported that topical lidocaine decreased the incidence of laryngospasm in children who had suffered a recent URTI. This was the only study we found that investigated the effect of lidocaine in preventing laryngospasm during general anaesthesia in these high-risk patients and we suggest that the efficacy of lidocaine in high-risk children, such as those exposed to passive smoking, should be investigated.

An important limitation to our meta-analysis concerned risk of bias. Anaesthetists were not blinded in four studies, and most studies did not describe the randomisation process or comment on allocation concealment. As a result, a high risk of bias was attributed to four studies and a low risk of bias was attributed to only one study. Thus, we downgraded the quality of evidence to moderate. Further studies with a more robust design are required to confirm our findings. In spite of this limitation, our systematic review and meta-analysis has important strengths. Firstly, the extensive search strategy without language restriction using different databases, including a pre-registration site, allowed us to retrieve many studies. As a result, we included one article in Spanish [44] and one published in abstract form only [38], which may contribute to reduce publication bias.

In conclusion, the results of this meta-analysis demonstrate that lidocaine is able to prevent laryngospasm during general anaesthesia in children (GRADE: moderate) and that both intravenous and topical administration are effective.

## Competing interests

No external funding and no competing interests declared.

## References


1. Olsson GL, Hallen B. Laryngospasm during anaesthesia. A computer-aided incidence study in 136,929 patients. *Acta Anaesthesiologica Scandinavica* 1984; **28**: 567–75.
2. Roy WL, Lerman J. Laryngospasm in paediatric anaesthesia. *Canadian Journal of Anesthesia* 1988; **35**: 93–8.
3. Gulhas N, Durmus M, Demirbilek S, Togal T, Ozturk E, Ersoy MO. The use of magnesium to prevent laryngospasm after tonsillectomy and adenoidectomy: a preliminary study. *Pediatric Anesthesia* 2003; **13**: 43–7.
4. Cavallone LF, Vannucci A. Review article: extubation of the difficult airway and extubation failure. *Anesthesia and Analgesia* 2013; **116**: 368–83.
5. Baraka A. Intravenous lidocaine controls extubation laryngospasm in children. *Anesthesia and Analgesia* 1978; **57**: 506–7.
6. Koç C, Kocaman F, Aygenç E, Ozdem C, Cekiç A. The use of preoperative lidocaine to prevent stridor and laryngospasm after tonsillectomy and adenoidectomy. *Otolaryngology–Head and Neck Surgery* 1998; **118**: 880–2.
7. Leicht P, Wisborg T, Chraemmer-Jørgensen B. Does intravenous lidocaine prevent laryngospasm after extubation in children? *Anesthesia and Analgesia* 1985; **64**: 1193–6.
8. Gefke K, Andersen LW, Friesel E. Lidocaine given intravenously as a suppressant of cough and laryngospasm in connection with extubation after tonsillectomy. *Acta Anaesthesiologica Scandinavica* 1983; **27**: 111–2.
9. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Medicine* 2009; **6**: e1000100.
10. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine* 2009; **6**: e1000097.
11. Higgins JP, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. www.cochrane.org/training/cochrane-handbook (accessed 15/02/2013).
12. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *British Medical Journal* 2008; **336**: 924–6.
13. Atkins D, Best D, Briss PA, et al. Grading quality of evidence and strength of recommendations. *British Medical Journal* 2004; **328**: 1490.
14. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics* 1994; **50**: 1088–101.
15. Hamilton ND, Hegarty M, Calder A, Erb TO, von Ungern-Sternberg BS. Does topical lidocaine before tracheal intubation attenuate airway responses in children? An observational audit. *Pediatric Anesthesia* 2012; **22**: 345–50.
16. Yörükoğlu D, Alanoğlu Z, Dilek UB, Can OS, Keçik Y. Comparison of different extubation techniques in lumbar surgery: prone extubation versus supine extubation with or without prior injection of intravenous lidocaine. *Journal of Neurosurgical Anesthesiology* 2006; **18**: 165–9.
17. Wetzel LE, Ancona AL, Cooper AS, Kortman AJ, Loniewski GB, Lebeck LL. The effectiveness of 4% intracuff lidocaine in reducing coughing during emergence from general anesthesia in smokers undergoing procedures lasting less than 1.5 hours. *American Association of Nurse Anesthetists Journal* 2008; **76**: 105–8.
18. Honarmand A, Safavi M. Beclomethasone inhaler versus intravenous lidocaine in the prevention of postoperative airway and throat complaints: a randomized, controlled trial. *Annals of Saudi Medicine* 2008; **28**: 11–6.
19. Chan ST, Tham CS. The effects of 2% lignocaine gel on incidence of retching with the use of the laryngeal mask airway. *Anaesthesia* 1995; **50**: 257–8.
20. Gefke K, Andersen LW, Friesel E. [Effect of intravenous lidocaine in laryngospasm]. *Ugeskrift for laeger* 1982; **144**: 2096–7.
21. Zeidan A, Halabi D, Baraka A. Aerosolized lidocaine for relief of extubation laryngospasm. *Anesthesia and Analgesia* 2005; **101**: 1563.
22. Minogue SC, Ralph J, Lampa MJ. Laryngotracheal topicalization with lidocaine before intubation decreases the incidence of coughing on emergence from general anesthesia. *Anesthesia and Analgesia* 2004; **99**: 1253–7.
23. Kaabachi O, Chettaoui O, Ouezini R, Abdelaziz AB, Cherif R, Kokki H. A ketamine-propofol admixture does not reduce the pain on injection compared with a lidocaine-propofol admixture. *Pediatric Anesthesia* 2007; **17**: 734–7.
24. Hooda S, Nandini, Kiran S. Comparison of topical and intravenous lignocaine with thiopentone for insertion of laryngeal mask airway. *Tropical Doctor* 2001; **31**: 120–1.
25. Navarro LH, Braz JR, Nakamura G, Lima RM, Silva F de P, Módolo NS. Effectiveness and safety of endotracheal tube cuffs filled with air versus filled with alkalinized lidocaine: a randomized clinical trial. *São Paulo Medical Journal* 2007; **125**: 322–8.
26. Huang CJ, Hsu YW, Chen CC, et al. Prevention of coughing induced by endotracheal tube during emergence from general anesthesia–a comparison between three different regimens of lidocaine filled in the endotracheal tube cuff. *Acta Anaesthesiologica Sinica* 1998; **36**: 81–6.
27. Yukioka H, Yoshimoto N, Nishimura K, Fujimori M. Intravenous lidocaine as a suppressant of coughing during tracheal intubation. *Anesthesia and Analgesia* 1985; **64**: 1189–92.
28. Diachun CAB, Tunink BP, Brock-Utne JG. Suppression of cough during emergence from general anesthesia: laryngotracheal lidocaine through a modified endotracheal tube. *Journal of Clinical Anesthesia* 2001; **13**: 447–51.
29. Johnson LA. Immediate reversal of severe laryngospasm by intranasally instilled lidocaine with epinephrine. *Annals of Emergency Medicine* 1985; **14**: 275–6.
30. Konrad C, Gerber H, Schnider T, Schüpfer G. Is an alkalinized lignocaine solution a better topical anaesthetic for intratracheal application? *European Journal of Anaesthesiology* 1997; **14**: 616–22.
31. Estebe JP, Delahaye S, Le Corre P, et al. Alkalinization of intracuff lidocaine and use of gel lubrication protect against tracheal tube-induced emergence phenomena. *British Journal of Anaesthesia* 2004; **92**: 361–6.
32. Zamora Lozano J, Cruz Villaseñor JA, Rodríguez Reyes J, Sánchez Rodríguez JP, Briones Corona G, Gallardo Alonso LA. [Comparison of topical, intravenous, and intracuff lidocaine for reducing coughing after extubation during emergence from general anesthesia]. *Revista Española de Anestesiología y Reanimación* 2007; **54**: 596–601.
33. Yu H, Chu Q, Liu J, Chen L, Wang Y, Zuo Y. EMLA® cream coated on endotracheal tube with or without epidural lidocaine reduces isoflurane requirement during general anesthesia. *Frontiers of Medicine* 2012; **6**: 302–6.


 

34. Navarro LH, Lima RM, Aguiar AS, Braz JR, Carness JM, Módolo NS. The effect of intracuff alkalinized 2% lidocaine on emergence coughing, sore throat, and hoarseness in smokers. *Revista da Associação Médica Brasileira* 2012; **58**: 248–53.
35. Yukioka H, Hayashi M, Terai T, Fujimori M. Intravenous lidocaine as a suppressant of coughing during tracheal intubation in elderly patients. *Anesthesia and Analgesia* 1993; **77**: 309–12.
36. Allahyary E, Taregh S. The comparison of intravenous magnesium sulfate and lidocaine to prevent laryngospasm after tonsillectomy and/or adenoidectomy. *British Journal of Anaesthesia* 2012; **108**: ii278–309.
37. Aljonaieh KI. The effect of intravenous lidocaine on post-extubation laryngospasm. 2012. http://www.clinicaltrials.gov/ct2/show/study/NCT01445847 (accessed 15/02/2013).
38. Bidwai AV, Rogers C, Stanley TH. Prevention of post-extubation laryngospasm after tonsilectomy. *Anesthesiology* 1979; **51**: S50.
39. Keller C, Sparr HJ, Brimacombe JR. Laryngeal mask lubrication. A comparative study of saline versus 2% lignocaine gel with cuff pressure control. *Anaesthesia* 1997; **52**: 592–7.
40. Mikawa K, Nishina K, Takao Y, Shiga M, Maekawa N, Obara H. Attenuation of cardiovascular responses to tracheal extubation: comparison of verapamil, lidocaine, and verapamil-lidocaine combination. *Anesthesia and Analgesia* 1997; **85**: 1005–10.
41. Estebe JP, Dollo G, Le Corre P, et al. Alkalinization of intracuff lidocaine improves endotracheal tube-induced emergence phenomena. *Anesthesia and Analgesia* 2002; **94**: 227–30.
42. Jee D, Park SY. Lidocaine sprayed down the endotracheal tube attenuates the airway-circulatory reflexes by local anesthesia during emergence and extubation. *Anesthesia and Analgesia* 2003; **96**: 293–7.
43. Fagan C, Frizelle HP, Laffey J, Hannon V, Carey M. The effects of intracuff lidocaine on endotracheal-tube-induced emergence phenomena after general anesthesia. *Anesthesia and Analgesia* 2000; **91**: 201–5.
44. Penaloza IV, Diaz MVP, Jimenez TD. Use of beclametazone dipropionate for prevention of post-intubation laryngospasm in pediatrics vs topical lidocaine. *Anestesia en Mexico* 1999; **11**: 162–6.
45. O'Neill B, Templeton JJ, Caramico L, Schreiner MS. The laryngeal mask airway in pediatric patients: factors affecting ease of use during insertion and emergence. *Anesthesia and Analgesia* 1994; **78**: 659–62.
46. Schebesta K, Güloglu E, Chiari A, Mayer N, Kimberger O. Topical lidocaine reduces the risk of perioperative airway complications in children with upper respiratory tract infections. *Canadian Journal of Anesthesia* 2010; **57**: 745–50.
47. Sanikop C, Bhat S. Efficacy of intravenous lidocaine in prevention of post extubation laryngospasm in children undergoing cleft palate surgeries. *Indian Journal of Anaesthesia* 2010; **54**: 132–6.
48. Staffel JG, Weissler MC, Tyler EP, Drake AF. The prevention of postoperative stridor and laryngospasm with topical lidocaine. *Archives of Otolaryngology-Head and Neck Surgery* 1991; **117**: 1123–8.
49. Altintaş F, Bozkurt P, Kaya G, Akkan G. Lidocaine 10% in the endotracheal tube cuff: blood concentrations, haemodynamic and clinical effects. *European Journal of Anaesthesiology* 2000; **17**: 436–42.
50. Estebe J-P, Gentili M, Le Corre P, Dollo G, Chevanne F, Ecoffey C. Alkalinization of intracuff lidocaine: efficacy and safety. *Anesthesia and Analgesia* 2005; **101**: 1536–41.
51. Shroff PP, Patil V. Efficacy of cuff inflation media to prevent postintubation-related emergence phenomenon: air, saline and alkalinized lignocaine. *European Journal of Anaesthesiology* 2009; **26**: 458–62.
52. Baik HJ, Kim YJ, Kim JH. Lidocaine given intravenously improves conditions for laryngeal mask airway insertion during propofol target-controlled infusion. *European Journal of Anaesthesiology* 2009; **26**: 377–81.
53. Rafiei MR, Arianpour N, Rezvani M, Ebrahimi A. Effects of intracuff dexamethasone on post-extubation reactions. *Journal of Research in Medical Sciences* 2012; **17**: 338–43.
54. Arslan IB, Kose I, Ciger E, Demirhan E, Gumussoy M, Cukurova I. Does topical anesthesia using aerosolized lidocaine inhibit the superior laryngeal nerve reflex? *Otolaryngology-Head and Neck Surgery* 2013; **149**: 466–72.
55. Hasanein R, El-Sayed W. The effect of nebulized lidocaine hydrochloride on emergence from sevoflurane anesthesia in children undergoing Tonsillectomy. *Egyptian Journal of Anaesthesia* 2013; **29**: 351–6.
56. Yamasaki H, Takahashi K, Yamamoto S, Yamamoto Y, Miyata Y, Terai T. Efficacy of endotracheal lidocaine administration with continuous infusion of remifentanil for attenuating tube-induced coughing during emergence from total intravenous anesthesia. *Journal of Anesthesia* 2013; **27**: 822–6.
57. Takekawa K, Yoshimi S, Kinoshita Y. Effects of intravenous lidocaine prior to intubation on postoperative airway symptoms. *Journal of Anesthesia* 2006; **20**: 44–7.
58. Fuller PB. The relationship between preintubation lidocaine and postanesthesia sore throat. *American Association of Nurse Anesthetists Journal* 1992; **60**: 374–8.
59. Hamill JF, Bedford RF, Weaver DC, Colohan AR. Lidocaine before endotracheal intubation: intravenous or laryngotracheal? *Anesthesiology* 1981; **55**: 578–81.
60. Erb TO, von Ungern-Sternberg BS, Keller K, Frei FJ. The effect of intravenous lidocaine on laryngeal and respiratory reflex responses in anaesthetised children. *Anaesthesia* 2013; **68**: 13–20.

 