adhesive tape, or finger[4] are also alternatives to emergency airway management to obtain a functional ETT. However, once this condition is allowed, the ETT exchange should be performed as soon as possible.[4]

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References

1. Duma A, Novak K, Schramm W: Tube-in-tube emergency airway management after a bitten endotracheal tube caused by repetitive transcranial electrical stimulation during spinal cord surgery. ANESTHESIOLOGY 2009; 111:1155–7
2. Peskin RM, Sachs SA: Intraoperative management of a partially severed endotracheal tube during orthognathic surgery. Anesth Prog 1986; 33:247–51
3. Chalkeidis O, Kalakonas A, Chaidutis C, Chotoumanidis C: Endotracheal tube cutting during neurosurgical operation. Eur J Anaesthesiol 2009; 26:533–4
4. Harrison P, Bacon DR, Lema MJ: Perforation and partial obstruction of an armored endotracheal tube. J Neurosurg Anesthesiol 1995; 7:121–3
5. Weiss M, Dullenkopf A, Gysin C, Dillier CM, Gerber AC: Shortcomings of cuffed paediatric tracheal tubes. Br J Anaesth 2004; 92:78–88
6. Doyle DJ, O'Grady KF. Physics and modeling of the airway, Benumof' Airway Management, 2nd edition. Edited by Hagberg CA. St. Louis, Mosby-Year Book Inc., 2007, pp 95–7
7. Ketzler JT, Landers DF: Management of a severed endotracheal tube during LeFort osteotomy. J Clin Anesth 1992; 4:144–6

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Ultrasound Guidance: Concerns and Safety Issues May Have Some Answers

To the Editor:

The letter by Cory[1] brings to attention the importance of being aware of the bioeffects of ultrasound. It is a topic close to my heart and hence was exciting to read. Some of his queries may already have an answer. I would like to highlight some of the changes in the past few decades that he may have missed by oversight.

The safety concerns based on more than four decades of animal research prompted many organizations including American Institute of Ultrasound in Medicine and other international organizations to perform an in-depth analysis of this issue to arrive at conclusions and recommendations.[2–5] These have been mostly comforting in that no human studies have yet identified a potential risk. But they all do warn about the need for continued vigilance, especially with the use of currently available ultrasound machines with capabilities for higher outputs.

The other change that has happened is the display of indices for potential harm. The Food and Drug Administration mandated that machines with higher acoustic outputs display the thermal and mechanical indices to qualify for track 3, which shifted the responsibility of monitoring to the end user.[6] These calculated indices based on the data derived from animal studies are worst-case scenario estimates for potential harm. Most modern machines are programmed to limit the indices by changing the pulse repetition frequency, the pulse duration, and so forth.

Various animal models of crush injury to nerves followed by insonation have shown faster recovery of function besides histologic signs of earlier myelination when compared with sham.[7–9] Ultrasound bioeffects on the nervous tissue seems to span from neurolysis with high-intensity focused ultrasound to changes in ion channels besides changes in amplitudes and latency with therapeutic ultrasound.[10–12] All these changes were demonstrated at higher intensities or at least the upper limits of the diagnostic ultrasound intensities. Citing the capabilities of ultrasound to cause neurolysis may be an extreme as one should not be denied the use of the excellent image guidance that ultrasound provides.

Although animal studies have shown myriad effects with insonation, many well-conducted epidemiologic studies have failed to demonstrate causality.[13,14] The claims about autism, dyslexia, and handedness with ultrasound exposure have been disproved by studies including a longitudinal follow-up of children whose mothers had more than one exposure to ultrasound during pregnancy.[14]

Many animal studies have shown the potential for nonthermal effects with ultrasound including inertial and noninertial cavitation especially in gas-containing bodies.[15] Ultrasound has been shown to produce high temperatures and also generate free radicals during cavitation.[6] But the threshold for both inertial and noninertial cavitation is lowered only with microbubble contrast agents and not with the larger bubbles as may be encountered during injections.[16] Cavitation, a frequency-dependent phenomenon, may be unlikely with the bubbles that he refers to.[17] It is further reduced as the radius of the bubble required for cavitation at the higher frequencies used in regional anesthesia and pain medicine becomes restricted to a very narrow range.[6] A small study looking at lung hemorrhage during transechocardiography found no intraoperative evidence of lung hemorrhage as seen in animals.[18] Human lung seems to be protected from nonthermal effects because of factors yet unknown.

As he mentions, the attenuation coefficient changes with fluid or injectate. Using the National Council for Radiation Protection deration may provide safety with low attenuation. But most importantly, keeping the indices and the duration of insonation within limits especially during use of power Doppler, a stationary mode, may be all that is necessary.[6] During the use of ultrasound guidance for regional anesthesia and pain medicine, mostly the B mode is used with constant movement of the transducer until the target is identified.

I do agree with him that the low-intensity values that ultrasound machines claim is derived and sometimes differ between machines, as all the manufactured machines do not

undergo standardization and only some machines undergo the laborious acoustic parameter assessment in the laboratory. This is mainly for cost and time savings, but the difference is likely to be small. But practicing vigilance may help to detect the unknown or an extremely rare event.

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References

1. Cory PC: Concerns regarding ultrasound-guided regional anesthesia. ANESTHESIOLOGY 2009; 111:1167–8
2. Fowlkes JB; Bioeffects Committee of the American Institute of Ultrasound in Medicine: American institute of ultrasound in medicine consensus report on potential bioeffects of diagnostic ultrasound: Executive summary. J Ultrasound Med 2008; 27:503–15
3. Barnett SB, Ter Haar GR, Ziskin MC, Rott H, Duck FA, Maeda K: International recommendations and guidelines for the safe use of diagnostic ultrasound in medicine. Ultrasound Med Biol 2000; 26:355–66
4. National Council for Radiation Protection and Measurements (NCRP): Exposure criteria for diagnostic ultrasound. Part 1. Criteria based on thermal mechanisms, NCRP Report No. 113, Bethesda, MD, NCRP Publications, 1992
5. Nelson TR, Fowlkes JB, Abramowicz JS, Church CC: Ultrasound biosafety considerations for the practicing sonographer and sonologist. J Ultrasound Med 2009; 28:139–50
6. O'Brien WD Jr: Ultrasound-biophysics mechanisms. Prog Biophys Mol Biol 2007; 93:212–55
7. Crisci AR, Ferreira AL: Low-intensity pulsed ultrasound accelerates the regeneration of the sciatic nerve after neurotomy in rats. Ultrasound Med Biol 2002; 28:1335–41
8. Mourad PD, Lazar DA, Curra FP, Mohr BC, Andrus KC, Avellino AM, McNutt LD, Crum LA, Kliot M: Ultrasound accelerates functional recovery after peripheral nerve damage. Neurosurgery 2001; 48:1136–40
9. Raso VV, Barbieri CH, Mazzer N, Fasan VS: Can therapeutic ultrasound influence the regeneration of peripheral nerves? J Neurosci Methods 2005; 142:185–92
10. Foley JL, Little JW, Vaezy S: Effects of high-intensity focused ultrasound on nerve conduction. Muscle Nerve 2008; 37:241–50
11. Kramer JF: Effect of therapeutic ultrasound intensity on subcutaneous tissue temperature and ulnar nerve conduction velocity. Am J Phys Med 1985; 64:1–9
12. Chapman IV, MacNally NA, Tucker S: Ultrasound-induced changes in rates of influx and efflux of potassium ions in rat thymocytes *in vitro.* Ultrasound Med Biol 1980; 6:47–58
13. Newnham JP, Doherty DA, Kendall GE, Zubrick SR, Landau LL, Stanley FJ: Effects of repeated prenatal ultrasound examinations on childhood outcome up to 8 years of age: Follow-up of a randomised controlled trial. Lancet 2004; 364:2038–44
14. Salvesen KA: Epidemiological prenatal ultrasound studies. Prog Biophys Mol Biol 2007; 93:295–300
15. Dalecki D: Mechanical bioeffects of ultrasound. Annu Rev Biomed Eng 2004; 6:229–48
16. Barnett SB, Duck F, Ziskin M: WFUMB symposium on safety of ultrasound in medicine: Conclusions and recommendations on biological effects and safety of ultrasound contrast agents, 2006. Ultrasound Med Biol 2007; 33:233–4
17. Miller DL: WFUMB safety symposium on echo-contrast agents: *In vitro* bioeffects. Ultrasound Med Biol 2007; 33:197–204
18. Meltzer RS, Adsumelli R, Risher WH, Hicks GL Jr, Stern DH, Shah PM, Wojtczak JA, Lustik SJ, Gayeski TE, Shapiro JR, Carstensen EL: Lack of lung hemorrhage in humans after intraoperative transesophageal echocardiography with ultrasound exposure conditions similar to those causing lung hemorrhage in laboratory animals. J Am Soc Echocardiogr 1998; 11:57–60

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Safety of Ultrasound-guided Regional Anesthesia

To the Editor:

Four years ago, ANESTHESIOLOGY published a clinical concepts and commentary article that reviewed the use of ultrasound guidance for regional anesthesia.[1] This article described the underlying principles and available literature of this nascent field. General efficacy and safety of these approaches have been borne out in a large number of subsequent clinical trials.[2] However, a recent letter to the editor has raised the theoretical concern that bioeffects may be harmful to patients undergoing regional anesthesia procedures guided by ultrasound.[3]

Although it is clear that there are thermal and mechanical bioeffects of ultrasound, there are no confirmed adverse bioeffects when diagnostic levels of ultrasound are used.* Most bioeffects simply dissipate during the duty cycle of pulse sequence ultrasound and are significantly attenuated by the perfusion of living tissue.[4] Moreover, when using a handheld probe for imaging during peripheral nerve block, it would be very unlikely for a transducer to be maintained in a fixed position for an extended period. Interestingly, some of the postulated bioeffects of high-intensity ultrasound actually include the promotion of nerve regeneration and conduction block,[5,6] two effects potentially beneficial to those patients undergoing regional anesthesia procedures. Nonetheless, prudent use of ultrasound means using the lowest levels of exposure to achieve the desired goals (as low as reasonably achievable principle).

When studied *in vitro*, the threshold for ultrasound producing reduction in peripheral nerve compound action potentials was approximately 100–200 W/cm^2 (continuous wave, 30-s burst, reported intensity as the spatial peak temporal average).[7] This reduction correlated with nerve temperature elevation from ultrasound exposure and was more pronounced at low frequencies. Irreversible effects only occurred at more than 400 W/cm^2, well above the current Food and Drug Administration imposed limit of 720 mW/cm^2 (intensity as the spatial peak temporal average) for diagnostic imaging.[8] Admittedly, the interaction between local anesthetic toxicity and ultrasound has not been experimentally studied by such models, and the concerns that have been raised will hopefully encourage such investigations.

* Statement on mammalian *in vivo* ultrasonic biological effects. Available at: http://www.aium.org/publications/statements.aspx. Accessed December 6, 2009.