British Journal of Anaesthesia **111** (3): 338–46 (2013)
Advance Access publication 23 April 2013 · doi:10.1093/bja/aet121

BJA

REVIEW ARTICLES

Cricoid pressure training using simulation: a systematic review and meta-analysis

R. L. Johnson[1]*, E. K. Cannon[1], C. B. Mantilla[1] and D. A. Cook[2]

[1] Department of Anesthesiology and [2] Department of Medicine and Office of Education Research, College of Medicine, Mayo Clinic, Rochester, MN, USA

* Corresponding author: 200 First Street, S.W., Rochester, MN 55905, USA. E-mail: johnson.rebecca1@mayo.edu

Editor's key points

- The authors have synthesized evidence of the role of simulation in improving cricoid pressure application.
- Simulation was found to have a positive impact on the skills of the trainees.
- There was also some evidence of short-term retention of skills.

Summary. Cricoid pressure (CP) is commonly applied during rapid sequence intubation and may be protective during induction of anaesthesia; however, CP application by untrained practitioners may not be performed optimally. The objective of this systematic review was to synthesize the evidence regarding effectiveness of technology-enhanced simulation training to improve efficacy of CP application. Electronic databases from inception through May 11, 2011 were searched. Eligible studies evaluated CP simulation training. Independent reviewers working in duplicate extracted study characteristics, validity, and outcomes data. Pooled effect size (ES) with 95% confidence intervals (CIs) were estimated from each study that compared technology-enhanced simulation with no intervention or with other methods of CP training using random-effects model. Twelve studies (772 trainees) evaluated CP training as an outcome. Nine studies reported information on baseline skill, with 23% of providers being able to achieve the target CP before training. In a meta-analysis of 10 studies (570 trainees), CP training resulted in a large favourable impact on skills among trainees compared with no intervention (pooled ES 1.18; 95% CI 0.85–1.51; $P<0.0001$). Four studies found evidence of skills retention for CP application after training, but for a limited time (<4 weeks). Comparative effectiveness research shows beneficial effects to force feedback training over training without feedback. Simulation training significantly improves the efficacy of CP application. Future studies might evaluate the clinical impact of training on CP application during rapid sequence intubation, and the comparative effectiveness of different training approaches.

Keywords: cricoid cartilage; education, medical; intubation; patient simulation

Cricoid pressure (CP) use was advocated by Sellick[1] in 1961 to provide some measure of protection against aspiration during induction of anaesthesia. Original descriptions of the 'Sellick manoeuvre' were vague. A one-handed technique of pressure application to the midline of the cricoid cartilage with 'firm' pressure to occlude the oesophagus against the fifth cervical vertebrae was described in Sellick's original paper. Later, Vanner and Asai[2] quantified the amount of effective CP force needed as 10 Newtons (N) before induction of anaesthesia, followed by an increase to 30 N for use in anesthetized patients. Untrained healthcare professionals may apply too little pressure to the anterior larynx providing unreliable protection against regurgitation that may lead to aspiration occurrences despite application of CP, or may apply too much pressure resulting in impaired ventilation or obstructed views for tracheal intubation.[3–5] Case reports document oesophageal rupture occurring because of excessive CP.[3] It is speculated that it is this misapplication of force that has led to the ineffectiveness and unsafe use of CP in clinical practice. Indeed, knowledge and application of CP is poor among untrained healthcare providers.[4–6] This knowledge gap among practitioners suggests that appropriate training could be a key factor in CP success, and conversely, that the absence of training could be partially responsible for the current disillusionment with the use of CP during rapid sequence intubation.

Simulation training using synthetic models or anatomical manikins improves patient safety and increases learner competence.[7] Systematic reviews show that technology-enhanced simulation in comparison with no training provides consistent benefits for learning patient-related outcomes among healthcare professionals.[8 9] Original studies on technology-enhanced CP simulation showed marked improvement in application of correct force, and simple training programmes over a short period of time can improve retention of correct CP application among a majority of participants.[10 11] However, we were unable to find a previous systematic synthesis of evidence on simulation-based training for application of CP. This systematic review aims to

critically examine the intervention of CP training/simulation compared with no intervention for CP training among healthcare providers. If technology-enhanced simulation training improves CP application, current judgements regarding the effectiveness and safety of CP application may need to be reconsidered. Armed with this information, anaesthesiologists could better determine the usefulness of CP application during airway management.

Methods

This study is a protocol-driven systematic review addressing the intervention technology-enhanced simulation of CP for training healthcare providers. The study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[12] The general methods were described previously;[8] and this study's specific methods are briefly summarized below.

Questions

This systematic review sought the answer to the questions: (i) is CP application improved with simulation training in comparison with no training? (ii) How is learning retained after CP simulation training?

Eligibility criteria

Eligible studies were original comparative studies, randomized or observational, published in any language that investigated the use of technology-enhanced simulation to teach CP application to healthcare providers at any stage in training or practice, in comparison with no intervention or an active simulation-based (e.g. application of CP on high-fidelity manikin) or non-simulation training activity (e.g. reading an article on the topic of CP). We followed previously defined criteria for technology-enhanced simulation.[8] Included studies specifically assessed learning of CP application as an outcome.

Study identification

An electronic search strategy specialist with expertise in conducting systematic reviews and content expert investigators conducted an electronic search through Ovid MEDLINE, Ovid EMBASE, EBSCO CINAHL, PsychINFO, ERIC, Thompson Reuters Web of Science, and Scopus. The full search strategy had been published elsewhere.[8] The last date of the search was May 11, 2011. This search was extended with an updated focused MEDLINE search in June 2012 using the search terms (cricoid pressure OR Sellick) AND ('simulation' OR simulate OR 'education' OR 'training'). This updated search yielded 100 articles of which nine were unique (i.e. were not identified in the original search). Additional studies were identified by review of the reference sections of all eligible studies and solicitation from content experts.

Inclusion was determined based on independent review of each of the identified articles by two study investigators. Eligibility of potential candidate studies (as determined by either reviewer) underwent full text review by the two reviewers working independently and in duplicate. The reviewers calibrated their judgements. Disagreements were harmonized by consensus.

Data collection

Reviewers working independently and using validated collection forms[8] extracted all data from the full text versions of eligible studies. Study characteristics included author, publication year, sample size, study population (age), training level of learners, clinical topic, training location (simulation centre or clinical environment), and outcomes. Additionally, several features of effective simulation were also coded. These features include feedback, use of repetition and multiple learning strategies, time spent learning, curricular integration, and the timing of outcome assessment (less than or greater than 1 month after training). Also, reviewers performed focused abstraction of selected additional information on training characteristics unique to CP simulation.

Study quality was independently assessed by two reviewers using the Medical Education Research Study Quality Instrument (MERSQI)[13] and an adaptation of the Newcastle-Ottawa scale (NOS) for cohort studies.[14]

Statistical analysis

SAS 9.1 (SAS Institute, Cary, NC, USA) software was used for all analyses. Statistical significance was defined by two-sided alpha of 0.05, and interpretations of clinical significance emphasized confidence intervals (CIs) in relation to Cohen's effect size (ES) classifications (>0.8=large, 0.5–0.8=moderate).[15]

Studies were grouped according to comparison (no-intervention, non-simulation-comparison, or simulation-comparison). We planned *a priori* to quantitatively pool, using meta-analysis, results whenever three or more studies evaluated a common comparison. We also planned *a priori* subgroup analyses based on study design (randomized *vs* non-randomized) and selected instructional design features (multiple *vs* few learning strategies, and the presence or absence of human standardized patient). *A priori* sensitivity analyses excluded studies with imprecise ES estimation, namely estimates using *P*-value upper limits or imputed standard deviations.

Heterogeneity (across-study inconsistency) was quantified using the I^2 statistic, which estimates the percentage of variability across studies not because of chance.[16 17] I^2 values $<25\%$ indicate low heterogeneity and values $>50\%$ indicate high heterogeneity. Random-effects models were used to pool weighted ESs when large inconsistency was discovered.

Additional qualitative synthesis was conducted on studies excluded from meta-analyses including descriptions of learners, the simulations studied, baseline skill level of participants and the outcomes of those studies.

Results

Trial flow

Our search yielded 10 912 articles from which we identified 988 comparative studies of simulation-based training. After screening, we found 12 studies[4 10 11 18–26] of