Educational Research and Methods

Retention of Neonatal Resuscitation Skills and Knowledge: A Randomized Controlled Trial

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Background and Objectives: *This study compared the effectiveness of two booster strategies designed to improve retention of skills and knowledge in neonatal resuscitation by family practice residents.* Methods: *Residents were randomly allocated to one of three groups: video, hands on, or control. Residents in the two experimental groups received a "booster" 3–5 months after the Neonatal Resuscitation Program (NRP) course. All participants completed the follow-up test 6–8 months after taking the course. The main outcome measures consisted of the NRP written examination and the performance checklists.* Results: *A total of 44 residents completed the study (video, n=13; hands-on, n=14; control, n=17). Overall, participants had significantly lower scores at follow-up than at baseline, indicating deterioration in both neonatal skills and knowledge. Residents in the hands-on booster group made significantly fewer errors across all five checklists in life-supporting but not in lifesaving scores than those allocated to the control and video groups.* Conclusions: *The beneficial effect of mannequin practice or video boosters on skills and knowledge retention was less than what had been anticipated, and no benefit could be demonstrated in comparison to the control group. Deteriorating knowledge and skills remain a major concern, since boostering by hands-on or video at 3–5 months do not seem to have an impact on the retention of knowledge or lifesaving skills.*

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Many family physicians in Canada and elsewhere perform resuscitation of newborns in distress.[1] To educate physicians about newborn resuscitation, a Neonatal Resuscitation Program (NRP) was developed and endorsed by the American Heart Association and the American Academy of Pediatrics,[2] and the Canadian Institute of Child Health developed National Guidelines for Neonatal Resuscitation.[3] Since its inception in 1987, more than 430,000 individuals have taken the NRP provider courses (minutes, NRP Steering Committee meeting, April 13–14, 1997).

Competent neonatal resuscitation requires a combination of theoretical knowledge and practical, hands-on skill. Although most individuals can successfully learn to perform neonatal resuscitation, knowledge and skill acquisition and retention have been shown to be quite separate in educational studies about cardiopulmonary resuscitation (CPR). Knowledge retention, as assessed by the American Heart Association tests, or other written tests, often does not decline at the rate that practical skill retention declines and, in many cases, remains high, while retention of skills decreases substantially.[4-9]

Concerns about the lack of CPR skill retention led researchers to investigate methods for improving retention. The evidence for the effectiveness of hands-on "booster" sessions in CPR is the strongest. Mannequin practice within 6 months after initial training and simple retesting for skills with correction of errors has shown promising results.[10] The timing of refresher courses has also been shown to be important. It was suggested that resuscitation skills are maintained at a stable level by 3–6 month refresher courses.[11] Most of the knowledge and skills acquisition and

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retention studies have been based on adult CPR courses, often in lay trainees, and may not be applicable to the NRP course or physicians or resident trainees.[4]

A study on the provision and evaluation of an NRP course in 190 nurses reported that experimental subjects receiving the program had significantly improved knowledge and skill performance.[12] After the course, knowledge, but not skill performance, was maintained at 6 months. These findings, along with the results of a study[4] involving family practice residents, provide evidence that the course adequately improves knowledge (in nurses and residents) and skills (in nurses), compared with pre-course levels.

However, neither of these two studies on the NRP course addressed the effectiveness of booster strategies on knowledge and skills retention. Only one study has investigated the effects of two forms of reinforcement on the retention of CPR skills. That study involved parents of high-risk infants.[13] The study groups that had hands-on reinforcement practice retained the most skills.

Our study compared the effectiveness of two booster strategies designed to improve retention of skills and knowledge in neonatal resuscitation by family practice residents.

Methods

The standard NRP course was taught in small groups (three to five residents per instructor) by our family medicine faculty, with the assistance of a neonatologist. All residents who successfully passed the NRP course and acquired provider status were eligible to participate in this study. Those residents who signed the consent form were then randomly allocated to one of three groups: 1) experimental group I (video). Three to five months after NRP course completion, residents viewed a video review of the NRP course and were given the opportunity for unsupervised mannequin practice, 2) experimental group II (hands-on). Three to five months after NRP course completion, residents received supervised hands-on practice booster training sessions with mannequins, including correction of errors by the supervisor, 3) control group (control). Residents in this group received no booster training sessions.

Interventions

Participants in the experimental group I (video) were exposed to a video booster session 3–5 months after obtaining provider status. The video[14] lasted approximately 26 minutes, and it summarized the steps taught in the NRP course. Mannequin training, the Neonatal Resuscitation Manual, and copies of the NRP checklists were available. The residents were encouraged to engage in self-directed practicing on the mannequin and review of the manual (without the presence of an instructor). A research assistant supervised scheduling and the video setup.

Participants in the experimental group II (hands-on) were exposed to a hands-on practice booster session, which entailed mannequin practice as set up in the NRP course, 3–5 months after obtaining provider status. Each session lasted for about 2 hours. A faculty member not involved in the teaching of the original NRP course or the follow-up exams took each participant through the resuscitation maneuvers and gave feedback to correct errors in skill performance.

As noted, participants assigned to the control group received no booster sessions. All study participants then completed a follow-up evaluation 6–8 months after taking the NRP course.

Evaluating Knowledge and Skills

For assessment of knowledge, we used the standard NRP written examinations. These were taken from the Neonatal Resuscitation Manual and were available to all residents, prior to the workshop, in their course material. For assessment of clinical skills, we designed detailed performance checklists. We identified five major scenarios (bag and mask equip-

Table 1

Scores on Neonatal Resuscitation Program Written Examination and Residents Who Obtained a Passing Score* on the Follow-up Examination

	STUDY GROUP			
Measure	*Control (n=17)*	*Hands-on (n=14)*	*Video (n=13)*	*Overall (n=44)*
Baseline written exam Mean (SD)	222 (13)	223 (10)	223 (8)	223 (10)
Follow-up written exam Mean (SD)	187 (16)	194 (12)	191 (21)	191 (16)
Achievement of passing score n (%)	8 (47)	9 (64)	9 (69)	26 (59)

* passing score = (191/239 = 80%)

SD—standard deviation

ment, apneic at birth without meconium, bradycardia, meconium staining, and intubation). We reviewed the Neonatal Resuscitation Manual and "Mega Code" to ensure that we included every step required for a competent resuscitation attempt. Our checklists were subsequently subdivided into skills that were "life-saving" and those that were merely "life-supporting." A copy of the performance checklist is available from the authors by request.

Evaluations of skills were conducted using the performance checklists; participants spent a designated amount of time at each of five stations, demonstrating every step in the Mega Code. All evaluations were conducted by five NRP instructors, who were members of the research team and who were blinded to participants' group membership. Each member of the research team was assigned to the same station throughout the study.

Scoring Knowledge and Skills

For scoring knowledge, the written NRP tests were graded by an assistant in the Department of Family Medicine who was blinded to the allocation status of participants. Following each course, and at follow-up 6–8 months later, this NRP written examination (which assessed knowledge) was administered. When tested at the time of the original course, an 80% (191/239) score for the knowledge test was required to obtain initial provider status.

For scoring skills retention, an error-free performance on the performance checklists for life-saving items was required to obtain initial provider status. Participants were allowed to commit errors on life-supporting items on each of the checklists and still obtain provider status. The same scoring criteria on the performance checklists were used at 6–8 month follow-up testing.

Data Analysis

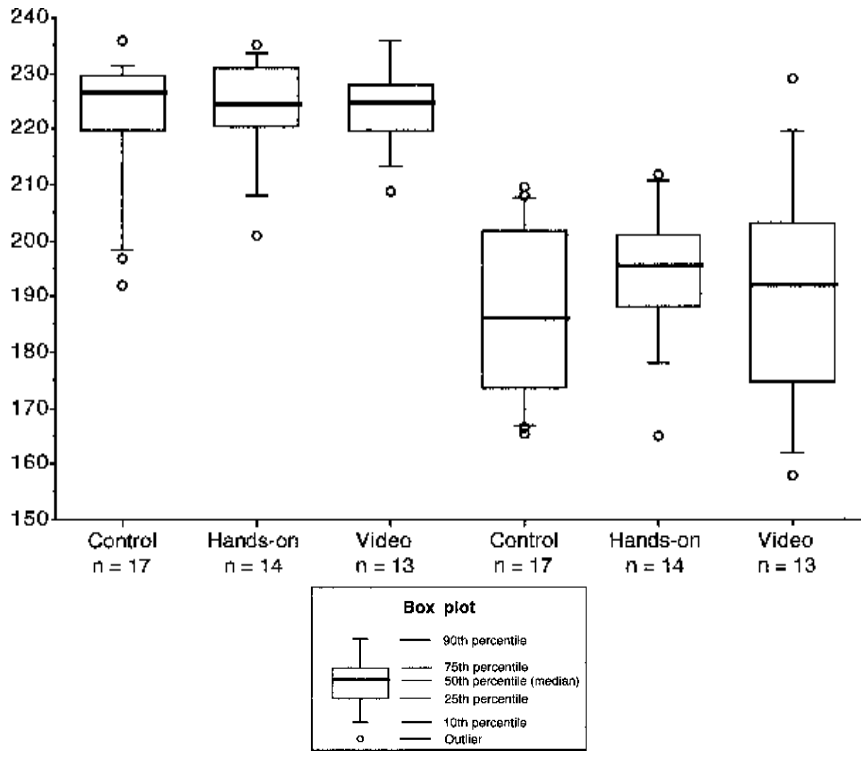
Data were collected on standard study forms and analyzed by microcomputer, using commercially available statistical software. Differences among the study groups were analyzed using chi-square tests for categorical variables and analysis of variance (ANOVA) for continuous measures. To assess the changes over the course of the study (ie, effect of booster strategies on knowledge retention) on the NRP scores, 3 x 2 ANOVAs were performed to examine group differences (control, video, and hands-on) over the two assessment periods (baseline and follow-up) treated as a repeated measure.[15] Relevant baseline scores were controlled for, when necessary, to eliminate confounding influences (ANCOVAs).[16] The independent variable of interest was the group allocation. Other analyses included calculation of the univariate statistics, comparison box plots, and correlational analysis. In all analyses, results were considered statistically significant at an alpha level of .05.

Results

Between July 1995 and April 1997, 92 residents participated in the NRP course; 75 of these residents gave consent for participation in this study, but only 59 of them became NRP providers and were, therefore,

Figure 1

Comparison Box Plots of Baseline and Follow-up Neonatal Resuscitation Program Written Test Scores (Knowledge)*



* according to group assignment. The three left-most boxes represent test scores immediately after the course. The right-most boxes represent test scores at follow-up 6–8 months later. Control, hands-on, and video represent the three study groups.

eligible to enroll in the study. Of these 59, 44 (75% of eligible participants) completed all aspects of the study. There were no statistically significant differences in baseline knowledge and skill scores between the 15 residents who dropped out and the 44 residents who completed the study protocol.

Knowledge Retention

The average initial NRP written score was 223 (223/239=93%; SD=10%). The mean follow-up test score for the same residents was 191 (191/239=80%; SD=16%) (Table 1). Initial scores did not differ significantly in the three groups. The follow-up test scores were significantly lower when compared to the baseline scores, regardless of group assignment. There was a significant time effect, F(1,41)=180, $P<.0001$, revealing differences in the NRP scores for all subjects over the study period. There were no other statistically significant differences. Comparison box plots of the data distribution for 44 residents who completed both written tests, by allocation group, are shown in Figure 1.

On follow-up knowledge testing, only 59% (26/44) of residents had scores above the acceptable passing level (80% or 191/239). There were no statistically significant differences in the proportion of residents who scored above the passing level according to the group allocation ($\chi^2=1.7$, $df=2$, $P=.423$).

Skill Retention

An error-free performance in lifesaving skills was a prerequisite to obtain NRP provider status and for participation in the study. Consequently, all participants had perfect scores (0 errors, 100%) in lifesaving clinical skills on all five checklists at baseline. None of the participants was able to achieve an error-free performance on all five checklists at the follow-up assessment. The mean performance score across all five performance checklists was 79% (SD=11%), and there were no statistically significant differences in overall score according to the allocation group [F(2,41)=1.26, $P=.284$]. However, there were some variations in specific scores based on group assignments. Residents in the hands-on booster group were significantly less likely to commit lifesaving errors on checklist #4 (meconium staining [$\chi^2=11$, $df=2$, $P=.004$]) than those allocated either to the control or video groups. These lifesaving scores are shown in Table 2. Comparison box plots of the lifesaving data distribution on the follow-up assessment for 44 residents by group assignment are shown in Figure 2.

The omission of life-supporting items (as compared with lifesaving items) on each checklist was not judged as indispensable or life-threatening. Nonetheless, there was a statistically significant overall decline in the mean life-supporting performance scores (from 92% to 66%) across all five checklists (F[1,41])=308.1, $P< .001$). Further, there was a statistically significant interaction effect of group with time (F[2,41]=5.09, $P=.011$), suggesting that decline in the mean life-supporting performance scores was not uniform across the three study groups. The follow-up tests indicated that those residents who were allocated to the hands-on group made significantly fewer errors at follow-up than the combined control

Table 2

Follow-up Test* Scores in Neonatal Resuscitation Program Lifesaving Skills

		STUDY GROUP			
Measure		*Control (n=17)*	*Hands-on (n=14)*	*Video (n=13)*	*Overall (n=44)*
Checklist #1: Bag and mask equipment					
	Follow-up: mean (SD)	90 (19)	93 (16)	95 (11)	92 (16)
	n (%)**	10 (59)	11 (79)	9 (69)	30 (68)
Checklist #2: Apneic at birth, no meconium					
	Follow-up: mean (SD)	75 (17)	72 (18)	79 (17)	75 (17)
	n (%)	2 (12)	1 (7)	3 (23)	6 (14)
Checklist #3: Bradycardia					
	Follow-up: mean (SD)	88 (11)	91 (13)	88 (10)	89 (11)
	n (%)	4 (24)	4 (29)	1 (8)	9 (20)
Checklist #4: Meconium staining					
	Follow-up: mean (SD)	63 (17)	79 (25)	71 (19)	70 (21)
	n (%)	1 (6)	7 (50)	1 (8)	9 (20)
Checklist #5: Intubation					
	Follow-up: mean (SD)	85 (15)	88 (16)	91 (18)	88 (16)
	n (%)	6 (35)	8 (57)	9 (69)	23 (52)
Mean score: All five checklists					
	Follow-up: mean (SD)	76 (11)	81 (12)	82 (9)	79 (11)
	n (%)	0 (0)	0 (0)	0 (0)	0 (0)

* All participants were required to have an error-free performance on the initial test.
** # (%) of residents who had an error-free performance

and video groups averaged across all five scenarios (72% versus 63%, respectively) (F[1,42]=5.7, *P*=.021). The results of these analyses are shown in Table 3 and Figure 3.

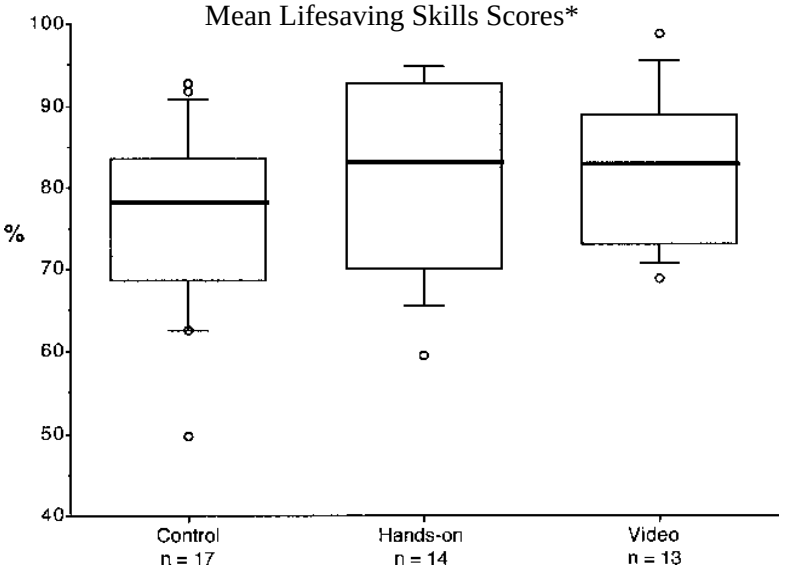
Discussion

This is the first study specifically designed to evaluate retention of knowledge and skills by physicians following NRP training. We found that knowledge and skills deteriorate over time and that the retention of psychomotor skills is substantially lower than the retention of the NRP knowledge. The beneficial effect of mannequin practice or video boosters on skills and knowledge retention was less than what had been anticipated, and no benefit could be demonstrated in comparison to the control group. Retrospective statistical power calculations revealed that this study had 80% power to detect differences at a two-sided 5% significance level of more than 16% on knowledge and more than 9% on the lifesaving scores (≥ 1 SD). Thus power was sufficient to detect large difference, though not medium to small effect sizes, which some readers might deem clinically important.

The NRP course is designed to teach resuscitation of newborn infants during the critical few minutes during and immediately following delivery so that health professionals can develop optimal knowledge and skill. About 25% of US[17] and 19% of Canadian[18] family physicians deliver babies. A 1994 survey of family medicine alumni who graduated from our program between 1973 and 1988 (response rate=70%) indicated that 24% were performing deliveries[19] and, therefore, had potential opportunity to use neonatal resuscitation skills. In 1994–1995 (the latest data available) family physicians in Canada attended 37% of all deliveries.[20] It is estimated that life support is needed in the birthing room or nursery for 6% of all newborns and for a much higher percentage of low-birth-weight newborns.[21] This means that a family physician attending two to three deliveries per month, or about 30 deliveries per year, can be expected to be called on to resuscitate a newborn approximately

Figure 2

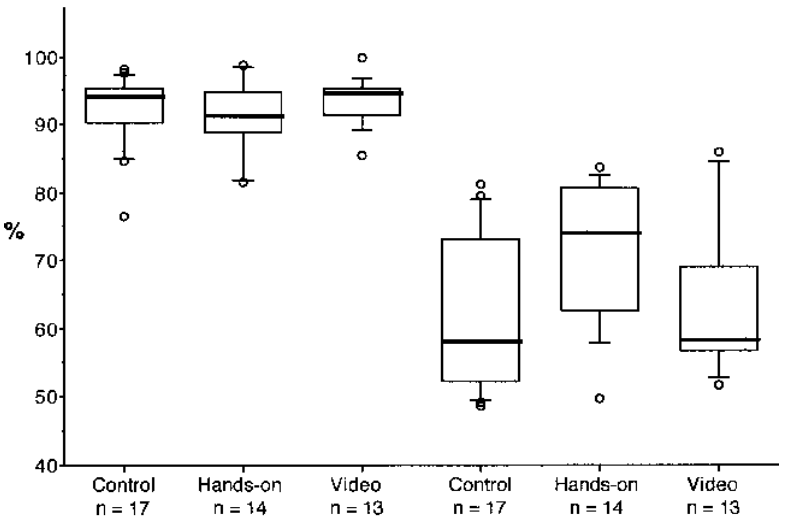
Comparison Box Plots of Follow-up Mean Lifesaving Skills Scores*



* according to group assignment. At baseline, all participants had a score of 100% correct. Control, hands-on, and video represent the three study groups. The Y axis indicates percent of items correct on the follow-up skill test.

Figure 3

Comparison Box Plots of Baseline and Follow-up Mean Life-supporting Skills*



* scores according to group assignment. The three left-most boxes represent test scores immediately after the course. The right-most boxes represent test scores at follow-up 6–8 months later. Control, hands-on, and video represent the three study groups. The Y axis indicates percent of items correct.

Table 3

Percent Scores* in Neonatal Resuscitation Program Life-supporting Skills at Baseline and Follow-up

	STUDY GROUP			
Measure	*Control (n=17) Mean (SD)*	*Hands-on (n=14) Mean (SD)*	*Video (n=13) Mean (SD)*	*Overall (n=44) Mean (SD)*
Checklist #1: Bag and mask equipment				
Baseline	87 (8)	82 (17)	87 (14)	85 (13)
Follow-up	54 (16)	69 (18)	61 (19)	61 (18)**
Checklist #2: Apneic at birth, no meconium				
Baseline	95 (5)	97 (6)	97 (3)	96 (5)
Follow-up	71 (15)	73 (17)	73 (22)	72 (17)**
Checklist #3: Bradycardia				
Baseline	94 (12)	92 (15)	95 (9)	94 (12)
Follow-up	60 (25)	76 (24)	60 (22)	65 (24)**
Checklist #4: Meconium staining				
Baseline	88 (16)	90 (7)	94 (7)	90 (11)
Follow-up	50 (16)	61 (25)	51 (20)	54 (21)**
Checklist #5: Intubation				
Baseline	96 (4)	94 (6)	95 (8)	95 (6)
Follow-up	76 (18)	79 (12)	76 (17)	77 (16)**
Mean score: All five checklists				
Baseline	92 (6)	91 (6)	94 (4)	92 (5)
Follow-up	62 (12)	72 (10)	64 (11)	66 (12)**

* Error-free performance = 100%

** All follow-up scores significantly different from baseline scores at $P<.0001$

once a year. Thus, emergency neonatal resuscitation is performed infrequently, but is a lifesaving procedure.

The Department of Family Medicine implemented mandatory NRP courses for residents at McGill University in explicit recognition that family physicians in Canada play an important role in the provision of pregnancy care. Currently, there are no data that govern the number of resuscitations necessary to promote competence. Intuitively, one would expect that frequent use of NRP skills in actual emergencies should improve skill retention. However, the existing evidence suggests that frequent use of CPR does not improve skill retention,[22,23] presumably because the performance of resuscitation without benefit of correction of errors does not improve skills retention. The poor retention of CPR and NRP skills also raises the broader issue of how to teach and maintain competence with regard to relatively less frequent but critical procedural skills.

Deteriorating knowledge and skills remain a major concern as boostering by hands-on or video training at 3–5 months did not seem to have the desired effect on retention of skills, but there are aspects of neonatal resuscitation that may benefit from either of these approaches.

Conclusions

Given the cost and logistic difficulty of organizing either hands-on or video booster sessions, the results of this study do not support recommendation for hands-on or video booster training. It remains for concerned medical educators to develop, use, and evaluate innovative strategies that may better address the long-standing problem of knowledge and skills deterioration following standard NRP courses.

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