The Ability to Provide Quality Chest Compressions Over Lacrosse Shoulder Pads

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Context: Performance of quality cardiopulmonary resuscitation is essential for improving patient outcomes. Performing compressions over football equipment inhibits compression depth and rate, but lacrosse equipment has not yet been studied.

Objective: To assess the effect of lacrosse shoulder pads on the ability to provide quality chest compressions on simulation manikins.

Design: Crossover study.

Setting: Simulation laboratory.

Patients or Other Participants: Thirty-six athletic trainers (12 men: $age = 33.3 \pm 9.7$ years; 24 women: $age = 33.4 \pm 9.8$ years).

Main Outcome Measure(s): No shoulder pads (NSP), Warrior Burn Hitman shoulder pads (WSP), and STX Cell II shoulder pads (SSP) were investigated. Outcomes were chestcompression depth (millimeters), rate (compressions per minute), rating of perceived exertion (0–10), hand-placement accuracy (%), and chest recoil (%).

Results: We observed a difference in mean compression depth among shoulder-pad conditions ($F_{2,213} = 3.73$, P = .03, ω^2

= 0.03), with a shallower depth during the WSP (54.1 ± 5.8 mm) than the NSP (56.8 ± 5.7 mm; *P* = .02) trials. However, no differences were found in mean compression rate ($F_{2,213} = 0.87$, P = .42, $\omega^2 = 0.001$, $1-\beta = .20$). We noted a difference in rating of perceived exertion scores ($F_{2,213} = 16.41$, P < .001, $\omega^2 = 0.12$). Compressions were more difficult during the SSP condition (4.1 ± 1.3) than during the NSP (2.9 ± 1.2; P < .001) and WSP (3.3 ± 1.1; P = .002) conditions. A difference was present in hand-placement accuracy among the 3 shoulder-pad conditions ($\chi^2_2 = 11.14$, P = .004). Hand-placement accuracy was better in the NSP than the SSP condition (P = .002) and the SSP than the WSP condition (P = .001).

Conclusions: Lacrosse shoulder pads did not inhibit the ability to administer chest compressions with adequate rate and depth. With appropriate training to improve hand placement, the pads may be left in place while cardiopulmonary resuscitation is initiated during sudden cardiac arrest.

Key Words: cardiopulmonary resuscitation, sudden cardiac arrest, protective equipment

Key Points

- Removing lacrosse shoulder pads before performing chest compressions may not be necessary.
- Chest compressions were administered with adequate rate and depth during trials in which 2 brands of shoulder pads were in place.
- Health care professionals with adequate hand-placement training can perform initial chest compressions over lacrosse shoulder pads while awaiting the delivery of an automated external defibrillator.

P erforming quality cardiopulmonary resuscitation (CPR) is essential for improving patient outcomes and decreasing mortality^{1,2} during sudden cardiac arrest in sport. The 2015 American Heart Association³ (AHA) guidelines stress the importance of chest compressions when CPR is performed. They must be 50-mm deep and administered at a rate of 100 to 120 per minute for CPR to be of high quality.³ However, protective equipment may interfere with the ability to perform chest compressions at an adequate depth and rate. If the shoulder pads do not interfere with performing quality CPR, perhaps initial compressions may be performed over the pads before an automated external defibrillator (AED) is brought to the scene, at which time exposing the chest through removing or retracting the pads would be appropriate.

Researchers have examined the effect of football shoulder pads on the ability to perform chest compressions.

Whereas initiating CPR was faster when football shoulder pads were left in place,⁴ the thickness and hard plastic coating of these pads precluded performing adequate chest compressions.^{5–7} Chest compressions were deeper when performed under the shoulder pads,^{5–7} when the shoulder pads were splayed open, or when the shoulder pads were removed.^{6,7} The percentage of compressions that were of adequate depth (50 mm) was also the lowest when the shoulder pads were in place,⁷ and a lower percentage of compressions allowed full chest recoil when the shoulder pads were left in place.⁴

Despite the findings for football protective equipment, no investigators to our knowledge have assessed whether lacrosse shoulder pads also inhibit performing high-quality CPR. Lacrosse is one of the fastest-growing sports in North America⁸ and has one of the highest rates of catastrophic injury.⁹ Lacrosse shoulder pads are typically only 2- to 3-

cm thick and made from high-density foam. In contrast, football shoulder pads may exceed 5 cm in thickness and contain a hard plastic shell that may make chest compressions more difficult to administer adequately. If performing chest compressions over the lacrosse shoulder pads does not interfere with the depth of chest compressions, health care professionals may be able to initiate CPR before removing or retracting the pads for AED placement and further CPR care, thus expediting the time to first compression. When initially caring for lacrosse athletes, adequate personnel may not be available to remove equipment, and the decision may be made to initiate care with equipment in place until adequately trained professionals arrive to assist.¹⁰ Therefore, the purpose of our study was to assess the effect of 2 different lacrosse shoulder pads on the ability to provide high-quality chest compressions on simulation manikins during 120 seconds of CPR intervention by athletic trainers (ATs).

METHODS

Participants

We recruited 36 ATs (12 men: age = 33.3 ± 9.7 years; 24 women: age = 33.4 ± 9.8 years) via e-mail using contact lists of preceptors from the mid-Atlantic region. All participants had current professional rescuer-level CPR certification (26 from the AHA, 10 from the American Red Cross) and held current state licenses to practice as ATs. Finally, no participant had any diagnosed skeletal, muscular, cardiovascular, or neurologic condition that would impair his or her ability to kneel and perform CPR. All participants provided written informed consent, and the study was approved by the institutional review boards of Seton Hall University and Lynchburg College.

Instruments

We used the Resusci Anne Q-CPR (Laerdal Medical, Wappingers Falls, NY) manikin with SimPad Reporter to collect the depth and rate of chest compressions during the CPR trials. The O-CPR manikins provide reliable measures of compression depth and rate, as well as other variables associated with the quality of CPR.¹¹ We placed the manikin in a supine position on the floor of the simulation laboratory because we wanted to better simulate what might happen during athletic competition, and reliability for chest-compression depth was higher with Q-CPR manikins placed on a firm surface.¹² We integrated the O-CPR manikin with the ETC Fusion Portable System (Kb Port, Allison Park, PA), which had 3 digital video cameras (Logitech HD; Kb Port) that captured manikin data simultaneously during each CPR trial. We used 2 sets of shoulder pads: Warrior Burn Hitman (WSP; Warrior Inc, Boston, MA) and STX Cell II (SSP; STX LLC, Baltimore, MD; Figure 1). We chose these 2 models based on anecdotal popularity. We also wanted to choose a pair that would be commonly used by offensive and midfield players (WSP) and defensive players (SSP). We measured the thickness of the pads (WSP = 15 mm, SSP = 17 mm) using a sliding caliper (Lafayette Instrument Co, Lafayette, IN).

Procedures

We placed ATs in pairs based on availability for the duration of the study and scheduled a time for the training session. Two data-collection sessions followed the training session, for a total of 3 sessions for each participant pair.

Training Session. During the first session, participants completed a demographic questionnaire. Next, they watched an informational video that the research team developed on the Resusci Anne O-CPR, which reviewed the components of high-quality CPR as defined by the AHA. After watching the video, participants could ask questions before performing a CPR simulation test on the manikin. We placed the manikin with no protective equipment in place supine on the floor of the simulation laboratory for the training session. We positioned foam mats at the head and to the manikin's left side for participant comfort while kneeling to perform CPR. The simulation tests occurred with each participant randomly assigned as either a compressor or ventilator during the 2minute CPR trial (approximately 5 cycles of CPR). A standard 2-rescuer AHA CPR protocol was used (30 compressions followed by 2 ventilations for each cycle). When the participants were in position, a member of the research team announced: "Begin CPR." The SimPad that contained a viewable 2-minute countdown clock with no other feedback was placed on the ground next to the participants. The manikin timer started when the first compression was delivered. Each pair had to earn an overall score greater than 80% for the simulation trials. The overall CPR score provided by the SimPad was calculated using an algorithm that takes into account incorrect compression depth, incorrect compression rate, incomplete release, inaccurate hand placement, flow-time fraction, incorrect ventilation volume, and incorrect ventilation rate. Pairs that did not reach 80% watched additional videos created by the research team on high-quality CPR and performing CPR on the manikin during the training mode, which allowed them to view adequate compression depth and rate in real time. A maximum of 30 minutes was allowed for additional training. When comfortable, the pair took a 3-minute break and then completed another CPR simulation test. If another attempt was required, these steps were repeated until the pair achieved a score of 80% or greater. After the first successful simulation test (overall score greater than 80%) and a 3-minute break, the participants switched positions to allow each to provide compressions. We followed the same steps to complete the simulation test with the participant roles reversed. The CPR proficiency testing was performed only on the manikin in the no-equipment condition.

Data-Collection Sessions. Approximately 7 days after the training session, participants reported to the simulation laboratory for the first data-collection session. They started the session by viewing the research-team-created video that provided information on the Q-CPR manikin and performing high-quality CPR. The videos were created following standardized procedures from the AHA for 2 trained rescuers. Next, participant pairs performed 6 trials (3 each as compressor) of CPR on the manikin with different combinations of protective equipment. The role of the compressor changed after each trial to allow additional rest for the participant in order to prevent any influence of fatigue. The manikin was positioned as in the training session. If shoulder pads were in place, participants were



Figure 1. Shoulder pads on manikins. A, Warrior Burn Hitman (Warrior Inc, Boston, MA). B, STX Cell II (STX LLC, Baltimore, MD).

instructed to perform chest compressions over the shoulder pads. Participants received no feedback on performance after each data-collection trial. After each 2-minute trial, participants completed a modified Borg13 rating of perceived exertion (RPE) form (range = 0-10, with 0 indicating rest; 5, hard; and 10, maximal effort) on paper and rested for 3 minutes before a new trial could begin. The RPE forms were separate and collected by the research team after each trial. Approximately 7 days later, participants returned for the second, and final, datacollection session. The procedures for the second session were replicated from the first: participants performed 6 CPR trials with different combinations of protective equipment after watching the same informational video. The equipment conditions were counterbalanced across the 2 data-collection sessions.

Statistical Analysis

A total of 216 trials were performed (6 trials by each of the 36 participants). Each participant performed 3 trials with shoulder pads on the manikin and 3 trials with no shoulder pads. We used counterbalancing, so that half (n = 18) of the participants used the WSP, and the other half (n = 18) used the SSP for their trials. Equipment made this an unbalanced 1×3 design.

Before settling on the analysis strategy, we analyzed the data for homogeneity of variance, normality, and independence. All assumptions underpinning the *F* test statistic were met. Therefore, we performed 3 separate 1-way analyses of variance for each continuous dependent variable of chest-compression depth (millimeters), compression rate (compressions per minute), and RPE. The independent variable for all 3 analyses was shoulder-pad condition (no shoulder pads [NSP], WSP, or SSP). For findings that were significant, we used post hoc analyses with a Bonferroni adjustment. Omega squared (ω^2) was

calculated as a measure of the effect size to determine the variation in the dependent variable explained by the independent variable. Hand-placement accuracy (percentage of compressions over the lower half of the sternum), chest-wall recoil (percentage of compressions allowing full chest recoil), and percentage of compressions not reaching adequate depth were provided by the SimPad and required no separate calculations. Given that all of these variables were expressed as percentages, we used nonparametric analyses to determine differences. A Kruskal-Wallis analysis was conducted for each of the 4 variables, with a Mann-Whitney test used for post hoc testing. Shoulder-pad condition remained the independent variable for these nonparametric analyses. Data were analyzed using SPSS (version 22.0; IBM Corp, Armonk, NY). The α level was set at .05 for all analyses.

RESULTS

All 36 participants started and completed the research project with their assigned partners. At the training session, 78% (n = 14) of our groups did not meet the standard of an 80% CPR score on the first attempt and required additional training. After demonstrating proficiency in 2-rescuer CPR, each group returned on 2 other occasions to complete a total of 12 trials. The descriptive results for the continuous variables during the 12 data-collection trials are presented in Table 1. We observed a difference among shoulder-pad conditions for mean compression depth ($F_{2,213} = 3.73$, P =.03, $\omega^2 = 0.03$), with a shallower depth for the WSP (54.1 \pm 5.8) than the NSP (56.8 \pm 5.7; P = .02). No other pairwise comparisons were different (P > .05). Mean compression rate did not differ among conditions ($F_{2,213} =$ 0.87, P = .42, $\omega^2 = 0.001$, $1-\beta = .20$). A difference was found in RPE scores ($F_{2,213} = 16.41$, P < .001, $\omega^2 = 0.12$) among shoulder-pad conditions. Bonferroni post hoc testing suggested that compressions were more difficult with the

	Table 1.	Descriptive Stat	istics for Conti	nuous Variable
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	Shoulder-Pad Condition, Mean \pm SD					
Chest Compression	No Shoulder Pads	Warrior Burn Hitman ^a	STX Cell II ^b	F _{2,213} Value	P Value	Effect Size
Depth, mm	56.8 ± 5.7	54.1 ± 5.8	56.0 ± 6.4	3.73	.03°	0.03
Compressions per min	115.0 ± 14.1	115.7 ± 15.9	112.5 ± 10.3	0.87	.42	0.001
Rating of perceived exertion	2.9 ± 1.2	3.3 ± 1.1	4.1 ± 1.3	16.41	<.001°	0.12

^a Warrior Inc, Boston, MA.

^b STX LLC, Baltimore, MD.

^c Indicates difference (P < .05).

SSP in place (4.1 ± 1.3) than with the NSP $(2.9 \pm 1.2; P < .001)$ and the WSP $(3.3 \pm 1.1; P = .002)$.

We noted a difference in hand-placement accuracy ($\chi^2_2 = 11.14$, P = .004) among the 3 shoulder-pad conditions. Whereas hand-placement accuracy between the NSP and the WSP was not different (P = .50; Table 2), it was different between the NSP and the SSP (P = .002) and between the SSP and the WSP (P = .001), suggesting that hand placement was more accurate in the SSP condition (Figure 2). No difference occurred among shoulder-pad conditions for chest-wall recoil ($\chi^2_2 = 1.11$, P = .57), which implied that the type of shoulder pads did not inhibit the ability of the chest to fully recoil for the next chest compression. The type of shoulder pads did not affect the percentage of compressions that were not reaching an adequate depth ($\chi^2_2 = 5.10$, P = .08).

DISCUSSION

Our main purpose was to determine if 2 brands of lacrosse shoulder pads altered the ability to provide quality chest compressions when CPR was performed over the pads when worn by simulation manikins. We found that the WSP condition inhibited chest-compression depth compared with the NSP condition. Whereas the chest compressions were deeper in the NSP than the WSP condition, chestcompression depths were within the recommended range for high-quality CPR as defined by the AHA.³ Therefore, although the findings were different, it may not be necessary to remove the shoulder pads from a lacrosse



Figure 2. Distribution of hand-placement accuracy for the 3 shoulder-pad conditions. Abbreviations: STX, STX Cell II (STX LLC, Baltimore, MD); Warrior, Warrior Burn Hitman (Warrior Inc, Boston, MA).

patient before administering chest compressions. Our participants achieved chest compressions greater than 5 cm in all 3 conditions. These findings differ from those reported in studies of football shoulder pads.^{4–7} We suspect the difference can be attributed to the fact that unlike football shoulder pads, lacrosse shoulder pads are much thinner and do not contain a hard plastic shell.

We were initially surprised that the SSP condition achieved a greater depth of compression than the WSP condition because these shoulder pads are 2 mm thicker. However, our RPE data and percentage of correct handplacement data may explain this phenomenon. It is likely that participants perceived that they exerted a greater amount of force when performing chest compressions over the SSP to account for the pad thickness, resulting in increased depth. The SSP condition also had the highest percentage of correct hand placement, which may have been the reason for achieving a greater depth of compression. The SSP did not extend below the sternum, but the WSP covered a larger portion of the thorax, which may have accounted for a decrease in the percentage of compressions with correct hand placement. Whereas we expected the NSP condition to have the most accurate hand placement, the SSP condition may have served as a target for correct hand placement, which allowed a higher percentage of compressions with correct hand placement.

When we analyzed the compression-rate data, we found no differences, which parallels findings from studies of football shoulder pads.^{4–7} Participants provided compressions within the recommended range both when shoulder pads were in place and when no shoulder pads were in place. These results may reflect the fact that leaving the thin pads in place did not cause the participants to change their cadence compared with the NSP condition. Also, our participants were highly skilled before the study started. We believe these explanations are reasonable because the shoulder pads were not thick enough to absorb the chest compressions. If the shoulder pads had been thicker and absorbed some of the compression, participants would have

Table 2.	Descriptive	Statistics	for Hand-Placement	Accuracy

Shoulder-Pad Condition	Range of Hand-Placement Accuracy, % ^a	Frequency of 100% Hand-Placement Accuracy
No shoulder pads	15–100	86/108
Warrior Burn Hitman ^b	0–100	42/54
STX Cell II ^c	81–100	53/54

^a Range (minimum to maximum) of percentage of compressions in the trial that were performed with accurate hand positioning.

^b Warrior Inc, Boston, MA.

° STX LLC, Baltimore, MD.

been required to take more time to reach adequate chestcompression depth.

Similarly to 2 of the studies^{5,6} on football shoulder pads, we found no differences among conditions for chest recoil. As expected, the NSP condition had the highest percentage of full chest recoil, indicating that the pads slightly inhibited full chest recoil, which was also reported in a study of football pads.⁴ Adequate chest recoil is an important part of quality CPR and may be inhibited if a responder is leaning on the patient. Not allowing full chest recoil can compromise venous return and cardiac output.¹

We demonstrated no differences in the percentage of compressions that reached adequate depth, which is inconsistent with what has been reported with football pads.^{4,6} Our finding supports the performance of compressions over the pads. Participants in 1 study⁴ on football shoulder pads produced a higher frequency of adequate compression depths over the pads, which the authors suggested represented a compensation on the part of the participants. In another study of football shoulder pads, Mihalik et al⁶ reported that compressions over the pads went to adequate depth only 15% of the time. Compression depth is a critical factor in performing quality CPR. The depth for all 3 of our conditions exceeded the minimum of 50 mm but stayed below the 60-mm maximum depth recommended by the AHA.¹

Another area emphasized by the AHA guidelines is minimizing the time to first compression.¹ In 506 patients with ventricular fibrillation that occurred outside a hospital, Christenson et al¹⁴ noted that chest-compression fraction (the proportion of time in which chest compressions are performed in each minute of CPR) was the best predictor of patient survival, lending support to the importance of expedient, high-quality chest compressions. We did not compare measures of time to first compression among the conditions or when removing or retracting the shoulder pads before compressions. When Del Rossi et al⁴ placed football shoulder pads on a manikin, it took an average of 24.5 seconds for participants to expose the chest via shoulder-pad retraction in order to perform compressions. Our participants reached the recommended depth of compression (50 mm) over the shoulder pads, making this a feasible option for responders to quickly initiate chest compressions. Whereas we do not know an exact time needed to retract or remove lacrosse shoulder pads, it is reasonable to believe that it will take longer than performing compressions over the shoulder pads. We believe the appropriate clinical approach for a lacrosse athlete in cardiac arrest is for 1 rescuer to immediately initiate chest compressions as another rescuer begins to cut the jersey to retract the shoulder pads for AED placement or further compressions directly over the chest. This approach is logical and should expedite the time to first compression.

LIMITATIONS AND FUTURE DIRECTIONS

Although our work is an important step in studying the application of CPR when lacrosse equipment is in place, we studied only 2 brands of lacrosse shoulder pads. We selected brands that we believed were widely used and would be similar to those worn by players of different positions. However, a wide variety of shoulder-pad models

is available, and others may produce different results. We also collected our data on a firm surface. Whether these results would translate to more sport-specific locations, such as turf or grass fields, is unknown. We tested each participant group to ensure CPR competency before data collection. Whereas we performed these tests to ensure that participants did not demonstrate ineffective skills due to a lack of familiarity with the manikin and the grading algorithm, generalizing our results to a broad range of health care professionals is difficult.¹⁵ Finally, participants completed trials with only NSP and 1 brand of shoulder pads. We acknowledge that fully crossing the design such that all participants used both brands of shoulder pads would have been a stronger approach.

We recommend that researchers examine different models of shoulder pads to improve generalizability. Perhaps investigators can replicate CPR chest compressions in locations that are more realistic for clinical practice and by clinicians who have not undergone recent training. Finally, it would be interesting to determine the amount of time required to remove the shoulder pads and expose the chest before CPR initiation. Currently, our data support initiating compressions over the shoulder pads to expedite the time to first compression; however, if time to remove shoulder pads to expose the chest is minimal, the time to first compression may still be expedient.

CONCLUSIONS

Based on the results of our initial study, it appears that removing lacrosse shoulder pads before performing chest compressions may not be necessary. Our participants were able to provide high-quality chest compressions over 2 brands of shoulder pads by obtaining a depth of 50 mm; however, it remains unknown if this expedient initiation of compressions is clinically relevant and will improve patient outcomes. Adequate rate and recoil were also achieved during trials when the 2 brands of shoulder pads were in place. Initiating CPR compressions over the shoulder pads before exposing the chest for AED pad placement and continued CPR compressions may lead to a positive patient outcome. When an AED is available, the shoulder pads should be removed or retracted to continue patient care.

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REFERENCES

- 1. Meaney PA, Bobrow BJ, Mancini ME, et al; CPR Quality Summit Investigators, American Heart Association Emergency Cardiovascular Care Committee, and Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Cardiopulmonary resuscitation quality: improving cardiac resuscitation outcomes both inside and outside the hospital. A consensus statement from the American Heart Association. *Circulation*. 2013;128(4):417–435.
- Ristagno G, Tang W, Chang YT, et al. The quality of chest compressions during cardiopulmonary resuscitation overrides importance of timing of defibrillation. *Chest.* 2007;132(1):70–75.
- 3. Highlights of the 2015 American Heart Association guidelines update for CPR and ECC. American Heart Association Web site.

https://eccguidelines.heart.org/wp-content/uploads/2015/10/2015-AHA-Guidelines-Highlights-English.pdf. Accessed August 7, 2017.

- 4. Del Rossi G, Bodkin D, Dhanani A, Courson R, Konin J. Protective athletic equipment slows initiation of CPR in simulated cardiac arrest. *Resuscitation*. 2011;82(7):908–912.
- Waninger KN, Goodbred A, Vanic K, et al. Adequate performance of cardiopulmonary resuscitation techniques during simulated cardiac arrest over and under protective equipment in football. *Clin J Sport Med.* 2014;24(4):280–283.
- Mihalik JP, Lynall RC, Fraser MA, et al. Football equipment removal improves chest compression and ventilation efficacy. *Prehosp Emerg Care*. 2016;20(5):578–585.
- Lynall RC, Mihalik JP, Swartz EE, et al. Effectiveness of chest compressions in various football equipment conditions. *Med Sci Sports Exerc.* 2014;46(5S):741–743.
- Hinton RY, Lincoln AE, Almquist JL, Douoguih WA, Sharma KM. Epidemiology of lacrosse injuries in high school-aged girls and boys: a 3-year prospective study. *Am J Sports Med.* 2005;33(9):1305–1314.
- Kucera KL, Yau R, Thomas LC, Wolff C, Cantu R. Catastrophic sports injury research thirty-second annual report: fall 1982–spring 2014. National Center for Catastrophic Sport Injury Research at the University of North Carolina at Chapel Hill Web site. https://nccsir. unc.edu/files/2013/10/NCCSIR-32nd-Annual-All-Sport-Report-

1982_2014.pdf. Published November 13, 2015. Accessed August 7, 2017.

- Montjoy M, Bowman T, Boergers R, Lu M, McClain C, Sgherza N. Descriptive study of athletic trainers' emergency management practices for equipment intensive sports [abstract]. J Athl Train. 2016;51(suppl 6):S-210.
- Beesems SG, Koster RW. Accurate feedback of chest compression depth on a manikin on a soft surface with correction for total body displacement. *Resuscitation*. 2014;85(11):1439–1443.
- Schober P, Krage R, Lagerburg V, van Groeningen D, Loer SA, Schwarte LA. Does the Q-CPR chest compression pad reliably determine compression depth during cardiopulmonary resuscitation?: 13AP1-7. *Eur J Anaesthesiol*. 2012;29(suppl 50):190.
- 13. Borg G. Borg's Perceived Exertion and Pain Scales. Champaign, IL: Human Kinetics; 1998.
- Christenson J, Andrusiek D, Everson-Stewart S, et al. Chest compression fraction determines survival in patients with out-ofhospital ventricular fibrillation. *Circulation*. 2009;120(13):1241– 1247.
- Yang CW, Yen ZS, McGowan JE, et al. A systematic review of retention of adult advanced life support knowledge and skills in healthcare providers. *Resuscitation*. 2012;83(9):1055–1060.

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