Original Research

"CPR Posture" for Hemorrhage Control

Nathan Phillip Charlton, Robert Solberg, Nici Singletary, Craig Goolsby, Justin Rizer, & William Woods

Abstract

Bleeding from traumatic injury is a major source of morbidity and mortality, however, little data is available to aid guidelines and curriculum developers in best practice of applying direct pressure when treating or teaching how to stop life-threatening hemorrhage.

Hypothesis: This study investigated the use of two-handed pressure with bent arms versus two-handed pressure with straight arms to apply direct pressure to a hemorrhage model.

Methods: Participants, recruited as a convenience sample, were randomized and instructed to use either two hands overlapping using arm strength only, or two hands overlapping with arms straight in a "CPR-like" position to apply force to a standardized hemorrhage control trainer with electronic feedback (Z-Medica), set to record a minimum pressure of 3-psi (155 mmHg); representing as satisfactory pressure to occlude blood flow. Participants were allowed to train for 30 seconds and then were asked to hold pressure at or above 3-psi for a three-minute time period. Participants were not given any feedback during testing. The program output reported the percent of time above the 3-psi pressure following participant completion of the three-minute time period.

Results: Thirty participants were enrolled and had data available for analysis. Demographics were statistically similar across groups. When using bent arms, participants provided pressure at or above 3-psi 63.7 % (SD 33.1) of the time. Participants using the "CPR posture" were above 3-psi 100% (SD 0) of the time [mean difference 36.27% (95% CI 18.78-53.75%). The difference between the two experimental arms remained statistically significant when examined by age, gender, or medical experience.

Conclusions: A straight-armed "CPR posture" allowed participants to successfully apply pressure to stop simulated bleeding, according to study parameters, 100% of the time. This information provides evidence about the most efficient way to provide high quality direct pressure to stop life-threatening hemorrhage. This method appears applicable to a broad demographic. As this posture is already widely taught in CPR classes, it can be readily adopted for teaching or controlling hemorrhage.

Traumatic injury is the leading cause of injury related morbidity and mortality throughout the world, resulting in millions of hospitalizations and deaths each year (World Health Organization, 2014). The leading cause of preventable mortality in these injured patients is uncontrolled hemorrhage which is cited as the primary cause of death in 35% of traumatic mortalities (Hodgetts, Mahoney, Russell, & Byers, 2006; Kauvar, Lefering & Wade, 2006). While the majority of first aid education organizations advocate for the use of direct pressure as first line therapy to stop external bleeding, guidelines give little instruction regarding the best methods of applying direct pressure, including hand or finger placement and mechanics of applying the pressure. Neither the European Resuscitation Council (ERC), the American Heart Association (AHA) nor the American Red Cross (ARC) guidelines comment on the best method of applying pressure (Markenson et al., 2010; Zideman et al., 2015). The ERC notes "there is a paucity of literature comparing different bleeding control strategies commonly employed by first aiders (Zideman et al., 2015). In addition, the primary literature cited by the ARC, the AHA and the ERC comparing methods of holding direct pressure comes primarily from in hospital studies of holding pressure after artery catheterization for a medical procedure (Koreny, Riedmuller, Nikfardjam, Siostrzonek, & Mullner, 2004; Lehmann, Heath-Lange, & Ferris, 1999; Mlekusch et al., 2006; Naimer & Chemla, 2000; Naimer, Anat, Katif, & Rescue Team, 2004; Naimer, Nash, Niv, & Lapid, 2004; Pillgram-Larsen & Mellesmo, 1992; Simon, Bumgarner, Clark, & Israel, 1998; Upponi et al., 2007; Walker, Cleary, & Higgins, 2001; Yadav, Ziada, Almany, Davis, & Castaneda, 2003). In a prior study, we demonstrated that a two-handed method of pressure application generated more pressure in a model of bleeding than a one-handed method (Charlton, Solberg, Rizer, Singletary, & Woods, 2018). The purpose of this study was to further evaluate two-handed methods of pressure application to determine if a straight arm method ('CPR posture') using body weight can provide more consistent pressure than a bent arm method. With this data we hope to better define the best methods of teaching bleeding control for life-threatening hemorrhage.

Methods

Study Setting, Participants and Instruments

This study was approved by the University of Virginia Institutional Review Board. Participants were recruited as a convenience sample from the common area of an office building at the University. A standardized bleeding simulator (Z-Medica Hemorrhage Control Trainer with Biofeedback, Z-Medica, Wallingford, CT, USA) was used as a model for this study. This device uses wireless technology to link to a computer tablet device with an application that provides visual feedback on the amount of pressure being applied to the training model. The program can be set to a predetermined minimal acceptable pressure in pounds per square inch (psi) and for a desired time period of pressure application. The program reports a percent above the specified pressure following participant completion of the specified time period, but is limited in detail to only this data, it does not output specific pressure recordings over time. For this research, the required minimum pressure was set at 3 psi (155 mHg) and for a duration of three minutes. This pressure was felt to be a reasonable systolic human adult blood pressure to occlude a blood vessel and was consistent with pressure achieved in prior work done by the authors with two hand methods of pressure application. The three-minute duration was also consistent with some hemostatic dressing manufacturer recommendations for minimum time of holding pressure (Z-Medica, 2018). Based on pilot data (unpublished), a sample size of 8 was needed to detect a 20% difference in percentage of time below the set parameters, using an alpha of 0.05 and with a power of 80%.

Study Design

After obtaining verbal consent, we collected basic demographic information including: gender, age, and degree of medical training. Participants were randomized, via randomization software at www.randomizer.org, to either a bent-arm (Figure 1) or straight-arm method (Figure 2) of pressure application. Participants were instructed to use either two hands overlapping with arms bent which allowed for pressure using arm strength only or two hands overlapping with arms straight in a "CPR posture" position, which allowed for body weight transmission to apply pressure. Each participant only performed one method during the study. Participants trained on the model for 30 seconds using their specified method. During this time, they were allowed to view the tablet screen, which graphed the applied pressure in real time and allowed the participant to demonstrate a 3-psi pressure to the observer. Following a brief rest period, participants then entered the study phase. They were asked to hold direct pressure at or above 3-psi for three minutes. Participants were not allowed to view the tablet during this study phase, and researchers did not give any feedback.

Figure 1: Bent arm method of pressure application

Figure 2: Straight arm method of pressure application (CPR posture)

Following the three-minute study period, researchers recorded the percent of time participants maintained pressure at or above the 3-psi minimum. Participants were not told the study objective, or that pressure was being measured. Researchers were not blinded during data collection, but researchers analyzing data were blinded to the groups.

Statistical Analysis

Demographics and pressure results were entered into a Microsoft Excel Version 2010 spreadsheet (Microsoft, Redmond, WA, USA). A t-test was used to analyze continuous variables; a Fisher's exact test was used to assess categorical variables.

Results

Thirty participants were enrolled and had all data available for analysis (see supplemental file). Demographics, age, and medical experience were similar across groups (see supplemental file).

Participants using bent arms provided pressure at or greater than 3-psi 63.7 % (SD 33.1) of the time, while participants using the straight-arm method maintained pressure at or greater than 3-psi 100% (SD 0) of the time. The mean difference between the groups was 36.27% (95% CI 18.78-53.75). The two methods remained statistically significant whether the participant was a layperson or medical provider ($p= 0.0075$ and $p = 0.0037$, respectively). Results remained similar when analyzed by gender or age ($p = 0.716$ and 0.061, respectively).

We observed that participants were typically able to provide significantly more pressure with the straight arm method, in the range of 12-17 psi, and more consistently able to maintain this over the three-minute time period (see Figure 3a example). This was in contrast to the bent arm method where we typically observed an initial peak of 3-6 psi followed by a gradual decline in pressure over time (see Figure 3b-example). However, this data could not be recorded with the device used. The bent arm method was also subjectively reported to be more fatiguing by the participants.

Discussion

In this simulated model of bleeding, participants generated a pressure at or above 3-psi for three minutes 100% of the time when using a CPR posture and only 64% of the time when using a bent arm method. This provides evidence about the most effective way to apply and presumably teach pressure to control life-threatening hemorrhage.

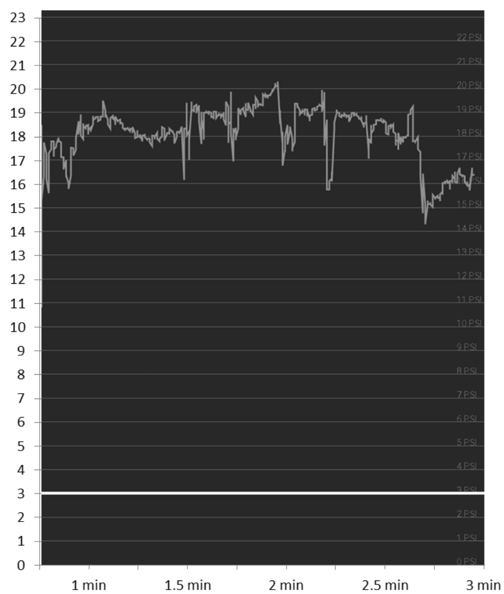

Figure 3: Pressure (PSI) vs Time Straight Arm Example

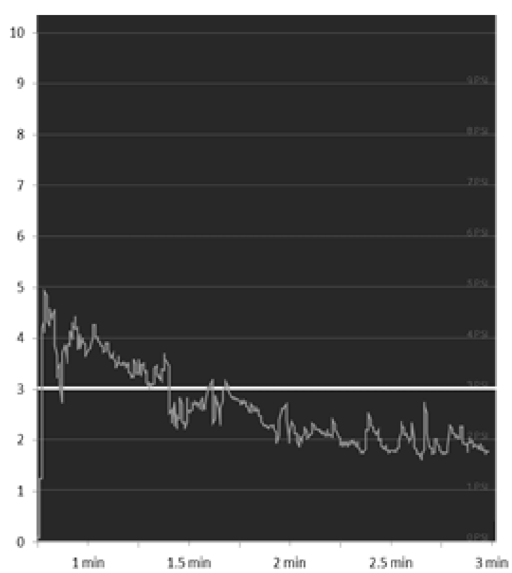

Figure 4: Pressure (PSI) vs Time Bent Arm Example

Bleeding varies in source and intensity. While some bleeding, such as an anterior nose bleed, may resolve with pressure from only two fingers, much more pressure may be needed to stop bleeding that is life threatening. Unfortunately, there has been little research on the best methods of applying direct pressure to stop bleeding, including both the techniques and the amount of pressure needed to stop bleeding. In a previous study, we demonstrated that using the digits of two hands to apply pressure generated more pressure than using the digits of one hand (Charlton, Solberg, Rizer, Singletary, & Woods, 2018). However, it was also seen that fatigue occurred over a short period of time and appeared to affect the amount of pressure placed on the simulated wound which could possible limit the effectiveness of pressure application.

There is little data available regarding the time or pressure needed to control life-threatening hemorrhage. In this study we chose 3-psi as it correlates with 155 mmHg, which was felt to represent a reasonable human adult systolic blood pressure. It is likely that less serious bleeding or more superficial bleeding may need less pressure than 3-psi in order to control bleeding. However, life-threatening bleeding or bleeding in deeper tissues may need more pressure, potentially resulting in more rapid fatigue. In addition, little information is available on the amount of time needed to stop life-threatening bleeding. Similar to pressure, the time needed to control bleeding likely varies depending on the source of the bleeding. Three minutes was chosen as it was listed as the time of recommended compression in the package insert of one standard hemostatic dressing (Z-Medica QuikClot bleeding control dressing, Z-folded package instructions). Longer time of pressure application would likely result in greater experienced fatigue.

To facilitate the instruction of first aid for life-threatening bleeding, it is necessary to find an easily teachable, efficient method of direct pressure application for bleeding control. The "CPR method" used in this study appears to provide a suitable method for applying a pressure greater than 155 mmHg for at least 3 minutes. As the posture is also taught in CPR classes it should be familiar to both students and instructors, so it can be easily adopted to provide specific instructions on how to apply pressure to patients with life-threatening bleeding which students will find easy to remember. Similar to dispatcher-assisted CPR, it should be amenable to just in time training and based on our sample this method appears to be applicable to a wide demographic.

Limitations

We recognize a number of limitations to this study. This study used a model of bleeding that did not provide any feedback during the study period. In a real-life situation, the presence of blood or continued bleeding may have prompted the provider to deliver more pressure. Conversely, while we did not provide verbal feedback to the participants during the study the lack of blinding may have led to inadvertent feedback to the participants. In addition, it is unclear what pressure is needed to stop various forms of bleeding. In this study we chose 3-psi as it corresponds with pressure to overcome a reasonable adult blood pressure. However, the data regarding the pressure needed to stop life-threatening hemorrhage is very limited. Certain body areas and bleeding types (e.g. arterial) may need a greater amounts of pressure applied; conversely, bleeding that is not life-threatening may not need this degree of pressure and, therefore, providers may not experience the same degree of fatigue as in our study. In addition, little data is available on the time and pressure needed for hemorrhage control and, as stated above, primarily comes from in-hospital procedures. Therefore, the three-minute study period may not be reflective the actual time needed to stop life-threatening hemorrhage.

Conclusion

This study demonstrates that using a "CPR posture" of pressure application provides more consistent pressure over three minutes than using arm strength alone. This data provides evidence to determine best practices for applying direct pressure, describing different techniques to apply it to control external hemorrhage. Further work will be needed to determine the degree of pressure generated and optimal pressures for stopping life threatening hemorrhage.*

* This article is the authors' opinions and does not represent the official policy or position of the Uniformed Services University, Defense Department, or US Government.

References

Charlton, N. P., Solberg, R., Rizer, J., Singletary, N., & Woods, W. A. (2018). Pressure Methods for Primary Hemorrhage Control: A Randomized Crossover Trial. *International Journal of First Aid Education*, 2(1). DOI: 10.21038/ijfa.2018.0011

Hodgetts, T. J., Mahoney, P. F., Russell, M. Q., & Byers, M. (2006). ABC to ABC: Redefining the military trauma paradigm. *Emergency Medicine Journal : EMJ*, *23*(10), 745-746. DOI: 23/10/745

Kauvar, D. S., Lefering, R., & Wade, C. E. (2006). Impact of hemorrhage on trauma outcome: An overview of epidemiology, clinical presentations, and therapeutic considerations. *The Journal of Trauma, 60*(6 Suppl), S3-11. DOI: 10.1097/01.ta.0000199961.02677.19

Koreny, M., Riedmuller, E., Nikfardjam, M., Siostrzonek, P., & Mullner, M. (2004). Arterial puncture closing devices compared with standard manual compression after cardiac catheterization: Systematic review and meta-analysis*. JAMA, 291*(3), 350-357. DOI: 10.1001/jama.291.3.350

Lehmann, K. G., Heath-Lange, S. J., & Ferris, S. T. (1999). Randomized comparison of hemostasis techniques after invasive cardiovascular procedures. *American Heart Journal, 138*(6 Pt 1), 1118-1125. DOI: S0002870399000642

Markenson, D., Ferguson, J. D., Chameides, L., Cassan, P., Chung, K. L., Epstein, J., . . . Singer, A. (2010). Part 17: First aid: 2010 American Heart Association and American Red Cross Guidelines for first aid. *Circulation, 122*(18 Suppl 3), S934-46. DOI: 10.1161/CIRCULATIONAHA.110.971150

Mlekusch, W., Dick, P., Haumer, M., Sabeti, S., Minar, E., & Schillinger, M. (2006). Arterial puncture site management after percutaneous transluminal procedures using a hemostatic wound dressing (closur P.A.D.) versus conventional manual compression: A randomized controlled trial. *Journal of Endovascular Therapy*, *13*(1), 23-31.

Naimer, S. A., Anat, N., Katif, G., & Rescue Team. (2004). Evaluation of techniques for treating the bleeding wound. *Injury, 35*(10), 974-979. DOI: 10.1016/S0020-1383(03)00316-4

Naimer, S. A., & Chemla, F. (2000). Elastic adhesive dressing treatment of bleeding wounds in trauma victims. *The American Journal of Emergency Medicine, 18*(7), 816-819. DOI: S0735-6757(00)15806-1

Naimer, S. A., Nash, M., Niv, A., & Lapid, O. (2004). Control of massive bleeding from facial gunshot wound with a compact elastic adhesive compression dressing. *The American Journal of Emergency Medicine, 22*(7), 586-588. DOI: S0735675704002426

Pillgram-Larsen, J., & Mellesmo, S. (1992). Not a tourniquet, but compressive dressing. experience from 68 traumatic amputations after injuries from mines. *Tidsskrift for Den Norske Laegeforening : Tidsskrift for Praktisk Medicin, Ny Raekke, 112*(17), 2188-2190.

Simon, A., Bumgarner, B., Clark, K., & Israel, S. (1998). Manual versus mechanical compression for femoral artery hemostasis after cardiac catheterization. *American Journal of Critical Care, 7*(4), 308-313.

Upponi, S. S., Ganeshan, A. G., Warakaulle, D. R., Phillips-Hughes, J., Boardman, P., & Uberoi, R. (2007). Angioseal versus manual compression for haemostasis following peripheral vascular diagnostic and interventional procedures--a randomized controlled trial. *European Journal of Radiology, 61*(2), 332-334.

Walker, S. B., Cleary, S., & Higgins, M. (2001). Comparison of the FemoStop device and manual pressure in reducing groin puncture site complications following coronary angioplasty and coronary stent placement. *International Journal of Nursing Practice, 7*(6), 366-375.

World Health Organization. (2014). Injuries and Violence: the facts 2014. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/149798/9789241508018_eng.pdf;jsessionid=FE9D74140EA60A9F253C74A889EE8F97?sequence=1

Yadav, J. S., Ziada, K. M., Almany, S., Davis, T. P., & Castaneda, F. (2003). Comparison of the QuickSeal femoral arterial closure system with manual compression following diagnostic and interventional catheterization procedures. *The American Journal of Cardiology, 91*(12), 1463-6, A6.

Z-Medica. (2018). QuikClot bleeding control dressing, Z-folded package instructions. Retrieved from https://www.rescue-essentials.com/quikclot-bleeding-control-dressing-3-inch-x-4-yard-z-folded/

Zideman, D. A., De Buck, E. D., Singletary, E. M., Cassan, P., Chalkias, A. F., Evans, T. R., . . . Vandekerckhove, P. G. (2015). European resuscitation council guidelines for resuscitation 2015 section 9. first aid. *Resuscitation, 95*, 278-287.