The Journal of Emergency Medicine, Vol. ■, No. ■, pp. 1–3, 2013

0736-4679/$ - see front matter

http://dx.doi.org/10.1016/j.jemermed.2013.03.036

Clinical Communications: OB/GYN

USE OF AN IMPEDANCE THRESHOLD DEVICE TO TREAT SEVERE HYPOTENSION IN A PREGNANT WOMAN: CASE REPORT AND REVIEW OF THE LITERATURE

Nicolas Segal, MD, PHD,*† David I. Page, EMT-P,‡ Charles J. Lick, MD,‡ Daryl D. Doering, MS, EMT-P,‡ and Demetris Yannopoulos, MD§

*Department of Emergency Medicine, University of Minnesota Medical Center, Minneapolis, Minnesota, †Service des Urgences, Hôpital Lariboisière, Assistance Publique-Hôpitaux de Paris, Université Paris, Paris, France, ‡Allina Medical Transportation, St Paul, Minnesota, and §Department Medicine-Cardiovascular Division, University of Minnesota Medical Center, University of Minnesota, Minneapolis, Minnesota

Reprint Address: Nicolas Segal, MD, PHD, Service des Urgences, Hôpital Lariboisière, Assistance Publique-Hôpitaux de Paris, 10, rue Ambroise Pare, 75010, Paris, France

□ **Abstract—Background: Impedance threshold device technology harnesses the patient's normal physiological mechanisms to increase circulation during hypotensive crises. We report the first clinical use of one version of this device on a spontaneously breathing hypotensive pregnant woman. Objective: The objective of our study was to report this case to help Emergency Medical Service rescue personnel to noninvasively treat hypotensive but conscious spontaneously breathing patients. Case Report: A 28-year-old woman who was 21 weeks pregnant developed frank syncope at home but recovered spontaneously. When Emergency Medical Service paramedics arrived, her initial blood pressure and heart rate were 115/80 mm Hg and 125 beats/min, respectively. She suddenly complained of feeling anxious and developed profound bradycardia and hypotension, followed by 20 s of asystole. An impedance threshold device (ResQGARD^{TM}) with −7 cmH_2O resistance to inspiration was rapidly applied using a facemask. After four spontaneous breaths, blood pressure increased from 62/40 mm Hg to 106/66 mm Hg. She was hemodynamically stable thereafter. Conclusions: In this case report, the multiple physiological effects of inspiration through −7 cmH_2O resistance helped this pregnant hypotensive patient to rapidly and noninvasively restore adequate perfusion and reduced the duration of her hypotensive episode. To our knowledge, this is the first report of this technology in a pregnant hypotensive but spontaneously breathing patient.** © **2013 Elsevier Inc.**

□ **Keywords—pregnancy; impedance threshold device; cardiovascular collapse; hypotension**

INTRODUCTION

Impedance threshold device technology harnesses a patient's normal physiological mechanisms to increase circulation during hypotensive states. We report the case of a spontaneously breathing pregnant woman suffering a sudden and severe case of hypotension with extreme bradycardia treated with an impedance threshold device (ITD-7 cmH_2O). To our knowledge, this is the first clinical report of the use of this device in a pregnant patient. The data sources were the Emergency Medical Service (EMS) record and the hospital file of the patient. The Institutional Review Board waived the need for informed consent.

CASE REPORT

A 28-year-old woman was previously diagnosed with postural tachycardia syndrome. She was 21 weeks pregnant with her second child: her first pregnancy was uneventful. On the morning of the current episode, she developed frank syncope and fell to the floor. Her family

RECEIVED: 14 January 2012; FINAL SUBMISSION RECEIVED: 31 October 2012;
ACCEPTED: 28 March 2013

called 911. The Advanced Life Support team found a conscious woman, without any distress, lying on her bed. She reported neck and back pain at the T4−5 level, as well as right knee pain. Her blood pressure was 115/80 mm Hg, her heart rate 125 beats/min, and the electrocardiogram (ECG) showed a normal sinus rhythm. A neck brace was placed and she was transported to the ambulance on a back board. Before the ambulance started to move, she suddenly complained of feeling anxious; the monitor showed the abrupt onset of bradycardia and hypotension, followed by 20 s of asystole. Left lateral positioning of the patient did not improve her status. An ITD-7 cmH_2O (ResQGARD^{TM}; Advanced Circulatory Systems, Inc., Roseville, MN) was rapidly applied using a facemask. After less than four spontaneous breaths, blood pressure increased from 62/40 to 106/66 mm Hg. An i.v. line was inserted and the patient received a normal saline solution at a rate of 1000 mL/h. The ECG rhythm strip revealed normal sinus rhythm at a rate of 98. She next complained that the face mask felt like it was very difficult to breathe, but she was instructed to continue to take slow deep breaths through the low level of inspiratory resistance created by the ITD-7. She continued to complain that she felt like she was suffocating. As she was hemodynamically stable, rescue personnel decided to remove the ITD-7 under close monitoring. Her blood pressure immediately decreased from 105/65 to 65/42 mm Hg. The ITD-7 was reapplied and after a couple of breaths blood pressure again rose to 105/70 mm Hg. Upon arrival at the Emergency Department, the ITD-7 was removed and the patient remained stable. In total, she had received 500 mL of a saline infusion and a 30-min treatment with the ITD-7. There were no known or reported immediate complications from ITD-7 use in this pregnant patient. No spinal injury was found. The patient developed bradycardia and hypotension for unclear reasons. She was hospitalized for 3 days in a telemetry ward and was stable. Her baby was born, at term, without complications. The hypotension and bradycardia were thought to be most likely secondary to a vasovagal event associated with her earlier diagnosis of postural hypotension, some relative dehydration, and supine hypotension syndrome of pregnancy.

DISCUSSION

The acute treatment for hypotension during a vasovagal event is to place the patient supine and, if symptoms persist, begin administration of a fluid therapy such as normal saline solution. In the case of a pregnant hypotensive patient, the supine position can be associated with a reduction in venous return, relative central hypovolemia, and hypotension. In this case report, the pregnant patient was treated acutely, noninvasively, and rapidly (before i.v. line placement) with an ITD-7 designed to increase circulation by a physiologic mechanism similar to a Mueller maneuver (1). The ITD is designed with a valve that closes when the pressure within the thorax is less than atmospheric pressure, and a second valve that opens at a preset negative intrathoracic pressure of −7 cmH_2O, thereby creating a resistance during inspiration. Supplemental O_2 can be delivered with the ITD-7. The ITD-7 is U.S. Food and Drug Administration approved. A recent study showed the feasibility, effectiveness, and safety of rapidly deploying the ITD by first responders to treat hypotension secondary to blood loss and trauma in the urban setting by EMS personnel (2). Use of the ITD-7 was recently thoroughly reviewed (3). It is important to note that this device is different in design from the ITD used to increase circulation in patients undergoing cardiopulmonary resuscitation. Indications, contraindications, and discontinuation criteria of the ITD-7 have been described previously by Convertino et al. (3).

The first ITD was originally designed to improve circulation during cardiopulmonary resuscitation after cardiac arrest (4,5). Additional research and a small change in design, e.g., reducing the inspiratory impedance to −7 cmH_2O, has resulted in a new and different device that provides a way to harness the thoracic pump to enhance circulation in spontaneously breathing patients. The new device, called the ITD-7 or ResQGARD, enhances the duration and magnitude of the intrathoracic vacuum with each inspiratory effort (4,6,7). The negative intrathoracic pressure generated during each inspiration draws more blood back into the heart, resulting in an immediate increase in stroke volume, cardiac output, and systolic/diastolic blood pressure in both animal models of hypotension and hypotensive patients (6–11). This intrathoracic vacuum, relative to the rest of the body, is also instantaneously transmitted to the brain by the veins surrounding the spinal column and perhaps through the cerebrospinal fluid via the intervertebral foramina (12). The ITD-7 has been studied in hypotensive swine and hypotensive humans (6–11,13–16). In randomized blinded studies, the ITD-7 has been demonstrated to reduce hypotension (9,14,15). It has also been used clinically to treat orthostatic intolerance and hemorrhagic shock (7–9, 11,15). ITD use has also been shown to improve short-term and 24-h survival of hemorrhagic shock (7,13). One important characteristic of the ITD is that it can “buy time” until more definitive treatment is available (9,8).

In our case report, these multiple physiological effects helped this pregnant hypotensive patient to rapidly and noninvasively restore adequate perfusion and reduced the duration of her hypotensive episode. To our knowledge, this is the first report of this technology in a pregnant hypotensive but spontaneously breathing patient. The

ITD is a new noninvasive tool to rapidly treat hypotensive patients that is particularly useful when i.v. access and fluids are not readily available for the treatment for hypotensive situations. It buys time for the patient to be transported to a medical or surgical team or for EMS to realize a definitive treatment. Use of the ITD should be encouraged in EMS services.

CONCLUSIONS

The ITD was an effective tool in our pregnant patient who developed hypotension secondary to vasovagal syncope; it provides an effective, rapid, and safe therapy to help improve hemodynamics and restore adequate circulation, especially when fluid resuscitation is not readily available.

REFERENCES

1. Condos WR Jr, Latham RD, Hoadley SD, Pasipoularides A. Hemodynamics of the Mueller maneuver in man: right and left heart micromanometry and Doppler echocardiography. Circulation 1987; 76:1020–8.
2. Convertino VA, Parquette B, Zeihr J, et al. Use of respiratory impedance in prehospital care of hypotensive patients associated with hemorrhage and trauma: a case series. J Trauma Acute Care Surg 2012;73(Suppl 1):S54–9.
3. Convertino VA, Ryan KL, Rickards CA, et al. Optimizing the respiratory pump: harnessing inspiratory resistance to treat systemic hypotension. Respir Care 2011;56:846–57.
4. Lurie K, Voelckel W, Plaisance P, et al. Use of an inspiratory impedance threshold valve during cardiopulmonary resuscitation: a progress report. Resuscitation 2000;44:219–30.
5. Plaisance P, Lurie KG, Payen D. Inspiratory impedance during active compression-decompression cardiopulmonary resuscitation: a randomized evaluation in patients in cardiac arrest. Circulation 2000;101:989–94.
6. Convertino VA, Cooke WH, Lurie KG. Inspiratory resistance as a potential treatment for orthostatic intolerance and hemorrhagic shock. Aviat Space Environ Med 2005;76:319–25.
7. Sigurdsson G, Yannopoulos D, McKnite SH, Sondeen JL, Benditt DG, Lurie KG. Effects of an inspiratory impedance threshold device on blood pressure and short term survival in spontaneously breathing hypovolemic pigs. Resuscitation 2006;68:399–404.
8. Lurie KG, Zielinski TM, McKnite SH, et al. Treatment of hypotension in pigs with an inspiratory impedance threshold device: a feasibility study. Crit Care Med 2004;32:1555–62.
9. Ryan KL, Cooke WH, Rickards CA, Lurie KG, Convertino VA. Breathing through an inspiratory threshold device improves stroke volume during central hypovolemia in humans. J Appl Physiol 2008;104:1402–9.
10. Melby DP, Lu F, Sakaguchi S, Zook M, Benditt DG. Increased impedance to inspiration ameliorates hemodynamic changes associated with movement to upright posture in orthostatic hypotension: a randomized blinded pilot study. Heart Rhythm 2007;4:128–35.
11. Smith SW, Parquette B, Lindstrom D, Metzger AK, Kopitzke J, Clinton J. An impedance threshold device increases blood pressure in hypotensive patients. J Emerg Med 2011;41:549–58.
12. Guerci AD, Shi AY, Levin H, Tsitlik J, Weisfeldt ML, Chandra N. Transmission of intrathoracic pressure to the intracranial space during cardiopulmonary resuscitation in dogs. Circ Res 1985;56: 20–30.
13. Yannopoulos D, McKnite S, Metzger A, Lurie KG. Intrathoracic pressure regulation improves 24-hour survival in a porcine model of hypovolemic shock. Anesth Analg 2007;104:157–62.
14. Convertino VA, Ratliff DA, Ryan KL, et al. Hemodynamics associated with breathing through an inspiratory impedance threshold device in human volunteers. Crit Care Med 2004;32(Suppl): S381–6.
15. Convertino VA, Ryan KL, Rickards CA, et al. Inspiratory resistance maintains arterial pressure during central hypovolemia: implications for treatment of patients with severe hemorrhage. Crit Care Med 2007;35:1145–52.
16. Rickards CA, Ryan KL, Cooke WH, Lurie KG, Convertino VA. Inspiratory resistance delays the reporting of symptoms with central hypovolemia: association with cerebral blood flow. Am J Physiol Regul Integr Comp Physiol 2007;293:R243–50.