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## Letter to the Editor

# Blood flow forward into the artery and backward into the vein during chest compression in out-of-hospital cardiac arrest



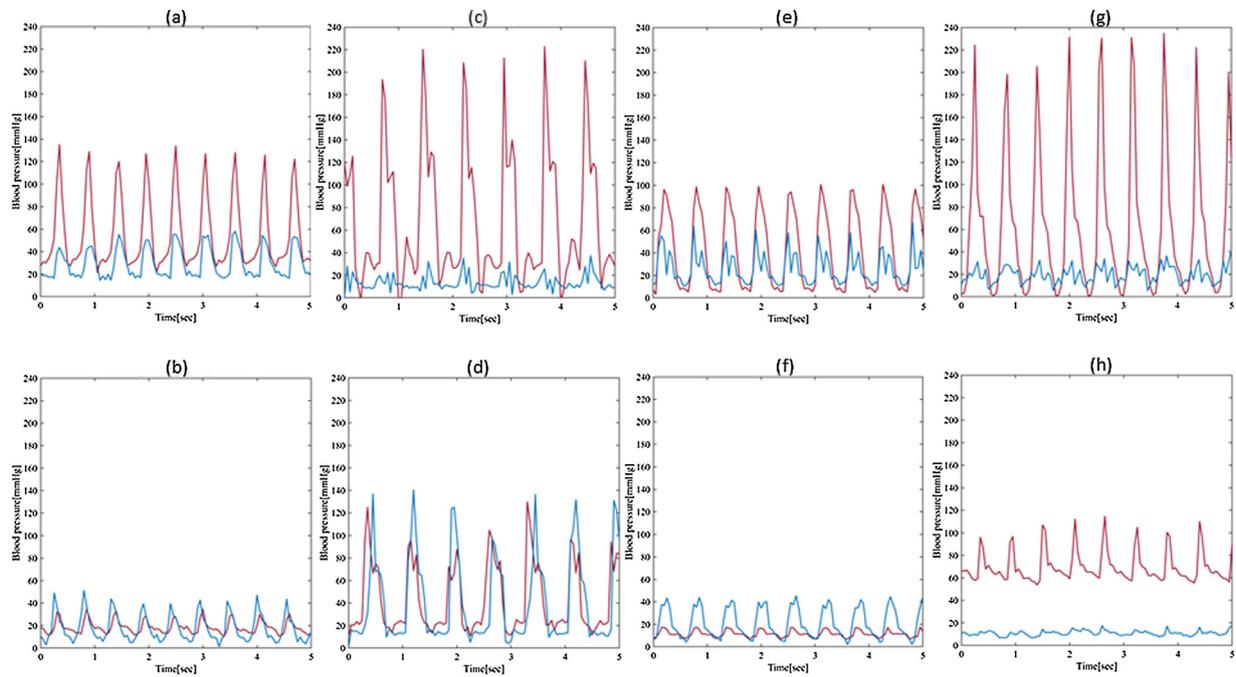
High quality of chest compression (CC) is one of the key components of cardiopulmonary resuscitation (CPR) for improving outcomes after cardiac arrest (CA).<sup>1</sup> However, little is known about the hemodynamic flow during CC. One prior study demonstrated that blood mainly flowed forward during CC.<sup>2</sup> Although another study reported that blood may flow backward into the jugular vein and inferior vena cava.<sup>3</sup> We describe the pattern of the hemodynamic flow by measuring arterial and venous pressures during CC. The objective of our present study was to determine the direction of blood flow as either forward or backward during CC.

This study was a prospective observational single-center study. Patients transported to our emergency department as out-of-hospital CA aged  $\geq 16$  years were enrolled. The exclusion criteria were as follows: those with traumatic out-of-hospital CA or who received extracorporeal membrane oxygenation. 4Fr catheter in femoral artery and vein was inserted as soon as possible at the emergency department using ultrasonography. The standard advanced cardiac life support was provided by manual or mechanical CC. Arterial and venous pressures were recorded continuously. We made graphs representing the data with MATLAB ver9.4 (R2018a). We obtained written informed consent from patients or their family for those with return of spontaneous circulation (ROSC) and passive consent by opt-out procedure for those without ROSC. The study protocol was approved by the Ethics Committee of University of Tsukuba Hospital.

We show 7 representative cases; Fig. 1 (a), (c), (e) and (g) shows the cases whose arterial pressure was dominant to the venous, and Fig. 1 (b), (d) and (f) shows the venous pressure was dominant to the arterial. Especially when we used mechanical CC, venous pressure was dominant to arterial as in Fig. 1 (d) and (f). Our study suggested that both arterial and venous dominant hemodynamic changes were observed during CPR with manual or mechanical CC.

The hemodynamic flow during CC was reported firstly that the venous pressure was similar to the arterial pressure.<sup>4</sup> After that study, Werner reported that the blood flowed forward during CC and little backward into the vein.<sup>2</sup> However, another study demonstrated that blood flows backward, and the contrast medium passed inferiorly reaching the iliac vein and superiorly into the brain in postmortem computed tomography.<sup>3</sup> In our study, the patients' venous pressure changed in the iliac vein, which suggested that the blood might be flowing backward during CC.

There were various hemodynamic theories about what occurs during CC: cardiac pump theory, thoracic pump theory, and so on.<sup>5</sup> Our findings suggested that hemodynamic flow during CC could not be explained by just one theory, however, the wide variations probably existed due to patients' backgrounds, including CA processes. Additionally, this is the first report that showed the detailed hemodynamic flow during mechanical CC. Importantly, the variation in hemodynamic status remains similar even after the quality of CC is constant with mechanical CC.



**Fig. 1 – There were the waveforms during CPR. Red waveforms are artery pressure waveforms, and Blue waveforms are venous pressure waveform. (a) 89 year-old woman with manual chest compression, (b) 87 year-old man with manual chest compression, (c) 86 year-old man with mechanical chest compression (Autopulse), (d) 81 year-old man with mechanical chest compression (Autopulse), (e) 88 year-old woman with mechanical chest compression (KOMSTAT 2300), (f) 44 year-old man with mechanical chest compression (KOMSTAT 2300), (g) 60 year-old woman with mechanical chest compression (LUCAS 3), (h) The waveform after ROSC of the same woman as in figure (g).**

In conclusion, our study revealed both hemodynamic patterns in which dominant arterial and venous pressures were observed with manual or mechanical CC. Blood flows forward or backward during CC despite various hemodynamic theories.

### Conflict of interest statement

This work was not supported.

### REFERENCES

1. Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: adult basic life support and cardiopulmonary resuscitation quality: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2015;132:S414–35.
2. Werner JA, Greene HL, Janko CL, Cobb LA. Visualization of cardiac valve motion in man during external chest compression using two-dimensional echocardiography. Implications regarding the mechanism of blood flow. *Circulation* 1981;63:1417–21.
3. Ruddy GN, Robinson C, Amoroso J, Coats T, Morgan B. Could post-mortem computed tomography angiography inform cardiopulmonary resuscitation research? *Resuscitation* 2017;121:34–40.

4. Weale FE, Rothwell-Jackson RL. The efficiency of cardiac massage. *Lancet* 1962;1:990–2.
5. Georgiou M, Papathanassoglou E, Xanthos T. Systematic review of the mechanisms driving effective blood flow during adult CPR. *Resuscitation* 2014;85:1586–93.

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