LETTERS TO THE EDITOR

Non-invasive cardiac output assessment in children

EDITOR,—We agree with Richardson and colleagues that it is important to be able to estimate changes in circulating blood volume in sick or injured children. When invasive methods for assessment of cardiac output (blood flow) are contraindicated, a non-invasive technique could be of great clinical benefit. Suprasternal sphygmomanometry is a relatively simple non-invasive technique for assessing the velocity profile of blood flow in the aortic arch, in this case, Doppler ultrasound. Stroke distance is a proxy for left ventricular stroke volume and can be derived mathematically from the measured systolic velocity-time curve. Our group has shown that this technique can produce reliable and reproducible measurements of stroke distance in normal, resting children if the limitations to its use are appreciated.1

Richardson and colleagues hypothesise that a single measurement of stroke distance in an ill child is a measure of absolute stroke volume, cardiac output for comparison with an established normal range of value.1 We do not believe that this is the best use of this technique for children when one reviews the available evidence. Furthermore, we are concerned about Richardson’s meaning of a “normal range” of values for stroke distance.1

Richardson and colleagues report a “normal range of values” for stroke distance at different ages. The authors imply that this “normal” range could be used to understand measurements made during future clinical studies. We understand that these children were being discharged from an accident and emergency (A&E) review clinic. However, we are not informed of the reasons for attendance or the length of time since the onset of their pathology. We can only assume that the majority of these children were being reviewed after minor or moderate illnesses, perhaps after blunt injury? Reporting these fundamental details is important if one wishes to accept Richardson’s hypothesis, mentioned above, and/or if one wishes to compare the results of Richardson et al with any other group (for example our own). With few exceptions, stroke distance in our study ranges from 20–30 cm (mean (SD) 24.4 (4.0) cm) whereas those of Richardson et al were somewhat higher (mean (SD) 31.8 (5.1) cm). This difference between these two studies is apparent at any given age. Confounding factors such as different observers, measuring techniques, and subjects can be important when attempting to establish norms for any physiological parameter. These two independent groups appear to have a similar age distribution, the same technique was adopted in the two centres and the same measuring instrument was used. However, other fundamental differences between the two groups of children could be important. This is particularly true if blunt injury was the cause for inclusion in Richardson’s study. Cardiovascular control mechanisms in adult patients are significantly affected by the presence of moderate blunt injury.1 These effects occur within three hours of injury and have not fully recovered by two weeks. In adults this results in a higher than expected blood pressure and a relative tachycardia. We are currently investigating this relationship in injured children arriving in A&E departments throughout the UK. Early results suggest that cardiovascular control mechanisms in all injured children, regardless of injury severity and age, are also significantly affected by the presence of blunt injury.1

Therefore, it would be helpful if Richardson and colleagues could define more clearly what they mean as “normal” children. Our own recently reported stroke distance measurements were from 143 normal, resting children in a nursery and a school.1 These children were similar in ages (2.4–11.5 years, median 6.6 years) to those reported by Richardson et al (2–14 years, mean 9.6 years). A positive and significant correlation between stroke distance and age was recorded in both studies (r = 0.339, p<0.0001 in our group compared with r=0.26, p<0.01 in Richardson’s group). However, from these two studies it appears that at any given age the range of stroke distance is rather wide. This accounts for the very weak relationship between stroke distance and age in both studies. Furthermore, we investigated the within-observer and between-observer variability for the measurement of stroke distance in our normal, resting children.1 Our results suggest that the best use of this technique, in its current form, is to monitor trend changes in blood flow for an individual patient over time. This is best achieved by making serial measurements of stroke distance for an individual patient using the same operator without reference to a “normal range” (for example as used clinically in the emergency department by Dark et al). Therefore we do not support the concept of Richardson and colleagues regarding the usefulness of a single stroke distance measurement and its comparison with established “normal ranges”. Furthermore, we would suggest that serial measurements provide far more than just “additional information”.

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1 Richardson JR, Ferguson J, Hiscox J, et al. Non-invasive assessment of cardiac output in children. Arch Dis Child 1998:78:304–7.
2 Childs C, Goldring S, Tunn W, et al. Suprasternal Doppler ultrasound assessment of stroke distance. Arch Dis Child 1998;79:251–9.
3 Little RA, Kirkman E, Driscoll P, et al. Preventable deaths after injury: why are the traditional “vital” signs poor indicators of blood loss? J Accid Emerg Med 1995;12:1–6.
4 Dark PM, Mackway-Jones K, Woodford M, et al. Systolic blood pressure and pulse rate in injured children: a new set of norms. Manchester UK Trauma Network, 1998 (unpublished).
5 Dark PM, Deloue HH, Hanson J, et al. The non-invasive haemodynamic left ventricular function during fluid resuscitation of patients with severe sepsis in the emergency department. Eur J Emerg Med 1998;5:105–6.

The authors reply

We agree with Childs and Dark that serial measurement of stroke distance has great potential for the diagnosis of hypovolaemia1 and monitoring the response of the sick or injured child to fluid resuscitation.2 Before any technique can be useful for monitoring patients it is important to have a reference for stroke distance for any meaningful interpretation of the results. The aim of our study was to establish a normal range for children “as a prelude to evaluating this technique in the assessment and management of hypovolaemia”1.

We are concerned about the differences in the measurements of stroke distance between Richardson’s results (normal of 20–30 cm) and our results (mean (SD) 31.8 (5.1) cm). Suprasternal sphygmomanometry utilises Doppler ultrasound to assess the velocity of blood flowing in the aortic arch. It therefore provides a velocity-time curve and a systolic blood pressure. Stroke distance is calculated. Mean peak aortic blood velocity in our study was identical to that measured by Light et al in 1978.3 Unfortunately, the velocity-time curve for stroke distance was not fully recovered. Also the results obtained in our study are fully consistent with the normal range for adults published by Mowat et al in 1983.3 The peak aortic blood velocity and stroke distance are slightly higher in children than in the youngest group of adults, as would be expected.

The suggestion that a history of moderate trauma could have been responsible for the haemodynamic changes resulting in our higher values for stroke distance is extremely unlikely. It is recognised that moderate trauma (such as fractures) can result in changes to baroreceptor reflex sensitivity which gives a persistent tachycardia not related to hypovolaemia.4 Children attending the A&E review clinic do not fall within this group. Significant long-term changes to be considered are those reviewed in other clinics. Those participating in our study had generally suffered minor sprains or skin wounds, and at the time of their involvement in this study their symptoms had resolved. Many “normal” children in school are likely to have suffered similar minor injuries within the preceding few weeks.

Other potential reasons for the differences in the results must also be considered. Childs’ study involved two operators who had three weeks’ experience of using the technique. It was reported that both operators “felt more at ease with the technique after a few days of intensive measurements during the first week of the study”.2 This may have added to measurement error in the earlier part of their study. It was noted that differences between the operators for any measurement was up to 5.3 cm. In our study all the measurements were from a single operator with seven months’ experience of using the technique on both children and adults.

It is possible that potential distortion of the child could result in an increase in heart rate and therefore, unless there is a significant increase in peak velocity of aortic blood flow, the stroke distance would be decreased. Our study ensured that the subjects were resting and not distressed. The measurement of blood pressure is uncomfortable and this was performed after stroke distance in all cases. Consequently, all the measurements of blood pressure were from a single operator with several months’ experience of using the technique on both children and adults.

We wish to stress that all children that potentially distorted the child could result in an increase in heart rate and therefore, unless there is a significant increase in peak velocity of aortic blood flow, the stroke distance would be decreased. Our study ensured that the subjects were resting and not distressed. The measurement of blood pressure is uncomfortable and this was performed after stroke distance in all cases. Consequently, all the measurements of blood pressure were from a single operator with several months’ experience of using the technique on both children and adults.

We agree that the technique, at its current level of development, has limitations which must be appreciated. These include a wide range in normal stroke distance values at any given age and the need for consistency in observer variability. To minimise errors we use single observer measurements and ensure that the observer is experienced in the use of this equipment. We are currently investigating the potential use of this technique to monitor the response of children to fluid resuscitation following trauma.

J Accid Emerg Med 1999;16:158–160.
Safe use of thrombolysis in acute myocardial infarction

Edwards.—The safe administration of thrombolysis in acute myocardial infarction (AMI) is a difficult area, and the contribution by Wald is not helpful. The author criticises the lack of evidence based practice among junior doctors in an area in which generally accepted evidence based guidelines are lacking. The author concludes that junior doctors probably under-utilise thrombolysis, but presents no evidence to support this; the respondents to this kind of questionnaire survey do not constitute evidence of current practice.

We agree that practice should be evidence based when possible, many of the perceived contraindications to thrombolysis are not evidence based, and may be said to err on the side of caution. However, it is important to appreciate that thrombolysis trials use a selected group of patients, and a lack of evidence of harm in a selected group does not constitute evidence of harmlessness when applied to the general population.

In Sheffield, thrombolysis in AMI has been audited in detail. We withhold thrombolysis within two months of a cerebrovascular accident, after recent head injury, and in uncontrolled hypertension, cerebral aneurysm, or tumour. In spite of this our cerebrovascular accident rate is 2.3%, higher than in the major trials. The risk of a cerebrovascular accident after thrombolysis is not an "intuitive fear", it is a real risk.

We have a written protocol and contraindications checklist to guide our junior doctors, with contraindications broadly similar to those presented by Wald. In the last year, only 2.5% of patients admitted with AMI had treatment withheld because of a contraindication. However, this group had a 30 day mortality of 45% (compared with 15.8% in thrombolysed patients).

The decision to withhold thrombolysis should not be made solely by a junior doctor. When the risk from thrombolysis is judged to be significant, urgent discussion with a cardiologist is appropriate. Systemic thrombolysis is not the only method of achieving reperfusion. The interests of these patients may be best served by exploring the obstacles preventing immediate angiography.

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Wald DS. Perceived contraindications to thrombolysis to support this: a survey in acute myocardial infarction. A survey in a teaching hospital. J Accid Emerg Med 1998;15:329–31.

The author replies

The survey shows a clear difference in opinion, among junior medical doctors, as to what constitutes a reason to withhold thrombolysis in AMI. This uncer-

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