Multi-centre in vivo Evaluation of MR Phase Contrast Flow Measurements

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Introduction

Despite a reasonably extensive literature on the application of cine phase contrast (CPC) velocity and flow mapping it seems apparent, at least anecdotally, that many users still do not actually believe the numbers that their systems produce. A number of previous studies have demonstrated the accuracy and precision of phase contrast flow measurements in phantoms [1]. However, it has not been demonstrated that this confidence carries over to the in-vivo situation. The aim of this study is therefore to perform a multi-centre, multi-vendor in-vivo evaluation of flow measurements in healthy volunteers using CPC flow mapping. Given the difficulty of obtaining a "gold-standard", an internal consistency trial was established to compare the systemic and pulmonary flow (Q_p/Q_s) ratio in a cohort of healthy volunteers, where the value should be close to unity.

Methods

53 healthy volunteers (36 male; 16 female; mean age 30; range 18-76), with no known intra cardiac shunts were recruited. Three sites (Cambridge, Frankfurt and Lund) participated in the study: volunteers were imaged on a 1.5T Sonata (Siemens Medical Solutions, Erlangen, Germany); a 1.5T Echospeed+ (GE Healthcare Technologies, Milwaukee, WI); and a 1.5T Intera (Philips Medical Systems, Best, The Netherlands). All images were acquired using a non-segmented, retrospectively gated, gradient echo cine phase contrast acquisition with the following parameters: minimum full TE with no flow compensation, TR approximately 15ms, flip angle 20^0, 32 phases, 34cm FOV, 5mm slice thickness, 2 NEX and an imaging matrix of 256x128. Velocity encoding between 100-250 cms^{-1} was applied through plane only. Pulmonary flow (Q_p) was measured in a slice perpendicular to the main pulmonary artery (MPA) and systemic flow (Q_s) in a slice perpendicular to the ascending aorta [2]. Each measurement was performed three times, i.e. six measurements in total, in an interleaved order to investigate the influence of physiological changes. All studies were analysed at the local site using local software and were also centrally analysed by two observers, one on two separate occasions, using the FLOW analysis package (Medis, Leiden, The Netherlands). Semi-automatic contouring was used for vessel delineation and no background correction was performed.

Results

The Qp and Qs measurements for each site as measured centrally are plotted in Figure 1. The Qp/Qs results are tabulated in Table 1. Intra subject repeatability, by one observer, for the three Qp/Qs measurements (n=53x3) was √(mean variance) = 0.09. The central observer repeatability (n=53) was (mean Qp/Qs difference) 0.003±0.02. The central inter-observer reproducibility (n=14) was (mean Qp/Qs difference) -0.005±0.048 and the inter-site observer reproducibility (n=40) was (mean Qp/Qs difference) -0.001±0.076. A paired two-tailed t-test was used to compare Qp/Qs measured at one local site (A) and the central site (P=0.922, n=40) and also to compare the intra-observer measurements (P=0.054, n=53) and the inter-observer measurements (P=0.439, n=14)

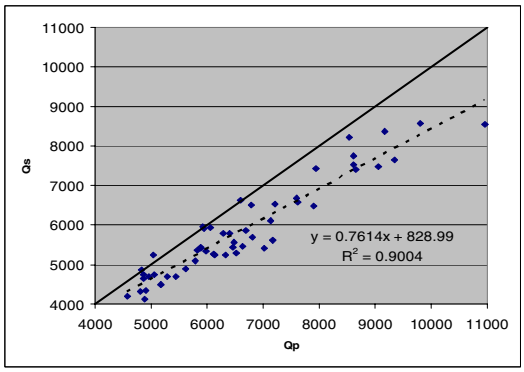

Figure 1. Regression graph (dotted) showing Qs vs. Qp for all data (n=53), together with the line of identity (solid).

Measurement	No. of volunteers	Q_p/Q_s
Local site A	40	1.13±0.05
Local site B	11	1.10±0.08
Local site C	2	0.98±0.03
Central site 1a	53	1.13±0.08*
Central site 1b	53	1.12±0.07
Central site 2	14	1.10±0.1

Table 1. Local site (A, B and C) and central site intra-observer (1a & 1b) and inter-observer (2) Q_p/Q_s measurements. *The range of measured Q_p/Q_s was 0.96-1.30.

Conclusions

There were no significant differences between the local and central measurements for site A or between intra or inter-observer measurements at the central site. As can be seen in Table 1 there is a 13% difference between Q_p and Q_s for the pooled analysis. This is higher than other reported variability's of between 3 and 5% [2]. However our results also demonstrated mean intra-subject measurement variability, i.e. from the six measurements, for one observer of 9%.

The findings of this study demonstrate that for a multi-site, multi-vendor, analysis, CPC flow measurements of Q_p/Q_s can be obtained with an acceptable accuracy for clinical usage, i.e. a small shunt is typically defined as $Q_p/Q_s < 1.4$, taking into account intra-subject flow variations and differences in acquisition and analysis systems. An acknowledged limitation of this study and therefore the statistical analysis is the unbalanced numbers from each site; however we plan to continue subject recruitment.

References

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