Determination of the right ventricular outflow tract velocity time integral (RVOT VTI) is an important part of the non-invasive investigation of pulmonary blood flow in adults, however, pediatric reference data are lacking. The normal range of RVOT velocity time integral (VTI) in adulthood is relatively stable, and differences can serve as indicators for changes in RV stroke volume. The RVOT VTI can provide information in patients with increased pulmonary blood flow, as this is a key anatomic and physiologic interface between the RV and pulmonary vasculature. In children with a moderate to large ASD an increased pulmonary blood flow is expected due to the volume overload of the RV, and therefore determination of the RVOT VTI might be useful. We examined growth related changes of RVOT VTI values in healthy children and the predictive value of RVOT VTI values in identifying enhanced pulmonary blood flow in ASD children.

Methods:
A prospective study was conducted in a group of 570 healthy children and children with a moderate-sized to large ASD. The ASD study group consisted of 52 patients (median age: 5.3 years; range: 0 - 18 years) with unrepaired isolated secundum type ASDs with moderate to large left-to-right shunting at the atrial level and signs of RV volume overload. The ASD size in our patients ranged from 6 mm to 16 mm. The effects of age, body length (BL), body weight (BW), and body surface area (BSA) on RVOT VTI values were determined. The predictive value of normal values stratified for age, BW, BL, and BSA was tested in our children with a moderate-sized to large ASD.

Results:
RVOT VTI normal values showed a positive correlation with age, BL, BSA, and BW in our healthy subjects. In our ASD patients with increased age the RVOT VTI z-scores increased. To investigate the ability of RVOT VTI upper normal reference ranges in detecting children with an ASD, we used a z-score of > +2 as cutoff point. Using age related RVOT VTI z-scores 37 out of our 52 ASD patients could be identified as having an increased RVOT VTI. In our ASD population RVOT VTI z-scores demonstrated a high specificity for detecting ASD patients (> 97%) with sensitivity up to 71%.

Discussion:
Measuring blood flow in the RVOT is independent of a possible stenosis of the pulmonary valve. The RVOT VTI may be useful for the evaluation of increased or decreased pulmonary blood flow in congenital heart disease patients. RVOT VTI normal values showed a positive correlation with age, BL, BSA, and BW in healthy subjects. This demonstrates an increase of pulmonary blood flow due to an increase in RV stroke volume with increasing age. We found enlarged RVOT VTI values of our ASD patients, more pronounced in younger children. With increasing age, BSA, BW, and BL z-scores of our ASD patients draw near to normal values, but are still higher compared to healthy patients. The easy to perform investigation of the RVOT VTI can detect hypervolemic or hypovolemic situations of the children. Future applications of RVOT VTI analysis may include its use as a screening tool to detect conditions with increased (e.g. ASD) and conditions with decreased (e.g. pulmonary artery hypertension) pulmonary blood flow.

Conclusion:
Measurement of the RVOT VTI represents a simple, rapid method to get information about pulmonary blood flow in children. We found elevated RVOT VTI values in our pediatric patients with moderate-sized to large ASDs when compared to healthy subjects. As an easy to measure, non-invasive parameter to detect increased pulmonary blood flow in pediatric ASD patients we suggest including the assessment of the RVOT VTI when evaluating pulmonary blood flow in patients with an ASD.

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