ROLE OF RADIONUCLIDE ANGIO-CARDIOGRAPHY FOR DETECTION AND QUANTITATION OF LEFT-TO-RIGHT SHUNT: KKUH EXPERIENCE

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The purpose of this retrospective study was to determine the accuracy of our radionuclide angiography (RNA) results. In this paper we present 38 patients who have undergone both RNA and oximetry during cardiac catheterization. The main difficulty in performing RNA is trying to determine whether or not gamma variate fit to the raw data is satisfactory. It requires experience to obtain correct and consistent results. We developed a computer program adopting Maltz and Treve's technique which aids in selecting the best fit. The RNA and oximetry results were compared. There was a good agreement between the Qp/Qs ratios calculated by RNA and oximetry ($r = 0.91$). In conclusion RNA is highly sensitive, noninvasive if good bolus is ensured and care is taken in selecting the best gamma fit.

THE ACCURATE MEASUREMENT OF LEFT-TO-RIGHT SHUNT (L-R shunt) is essential in patients with congenital heart anomalies. Radionuclide angiocardiography (RNA) is a noninvasive technique used for the detection and quantitation of L-R shunt.[1,2] The studies are noninvasive, rapid and expose patients to relatively low radiation dose. Circulatory dynamics are not disturbed and no exposure to radiographic contrast media is necessary. To provide accurate quantitation of L-R shunts, two area ratio techniques have been developed. These techniques calculate shunt size from a ratio of areas under the pulmonary time activity curve. The main difficulty in performing this technique is the determination of whether or not gamma variate fit to the raw data is satisfactory. Since the program for shunt quantification was not available we have developed a computer program adopting the technique by Maltz and Treves.[3,4] The program analyzes pulmonary flow using a gamma variate least square fit to radionuclide pulmonary dilution curve (Qp/Qs ratio). The method adapted by us minimizes errors by automatically obtaining the points that are most adequate and selecting the best fitting curve from various attempts with the option of operator intervention. (Here we present results from 38 patients who underwent both RNA and oximetry during cardiac catheterization).

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Patients and Method

We studied 38 patients (22 males and 16 females), who were referred to our department with suspected L-R shunt. They were aged 5 to 70 y (mean 26 y). Care was taken to exclude patients with major pulmonary or tricuspid insufficiency, as well as patients with low cardiac output. Patients with a ratio of pulmonary to systemic flow greater than four to one, estimated by either method were not included in the series.

All studies were performed with the patient in supine position under a General Electric gamma camera with low energy all-purpose collimator. A

compact bolus of 555 mbq (15 mCi/M^2) in 0.4 to 0.5 mL 99mTc DTPA or Pertechnetate (15 min after administration of pyrophosphate for in-vivo red blood cell labelling to be followed by radionuclide ventriculogram for ejection fraction estimation) was injected rapidly in the right antecubital fossa and flushed with saline. Data was collected at a rate of 0.25 sec/frame for 30 sec. Care was taken to ensure a good quality bolus.

Data Analysis

Region of interest (ROI) was drawn over the superior vena cava (SVC) and on peripheral lung fields avoiding the main blood vessels, and time activity curves (TAC) were generated. The SVC curve was used to evaluate the bolus score. Only bolus with a score of < 4 sec was accepted. On the pulmonary peak, gamma variate fit was performed and the counts under the curve were noted (A1). The pulmonary fit was subtracted from the original curve resulting in recirculation peak and counts under the curve were noted (A2). The following formula was used to estimate L-R shunt (Figure 1).

$$\text{L-R shunt} = \frac{\text{A1 (Pulmonary)}}{\text{A1-A2 (systemic circulation)}}$$

Qp/Qs ratio ≤ 1.2 was considered normal

Qp/Qs value > 1.2 to 3.1 was considered positive for L-R shunt

Values > 3.1 were considered unreliable

The pulmonary to systemic flow was calculated from oximetric data by using Fick's principle.

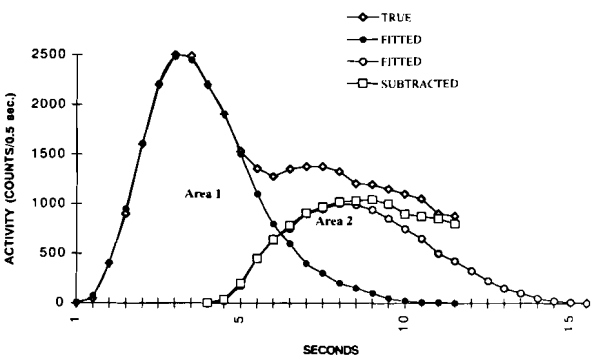

Figure 1: Abnormal pulmonary time activity curve. The two gamma function-determined areas and the method determining the Qp/Qs ratio are shown.

Table 1. *Diagnosis of patients.*

Diagnosis	No. of patients (n = 38)
ASD	17
VSD	10
PDA	3
Normal	8

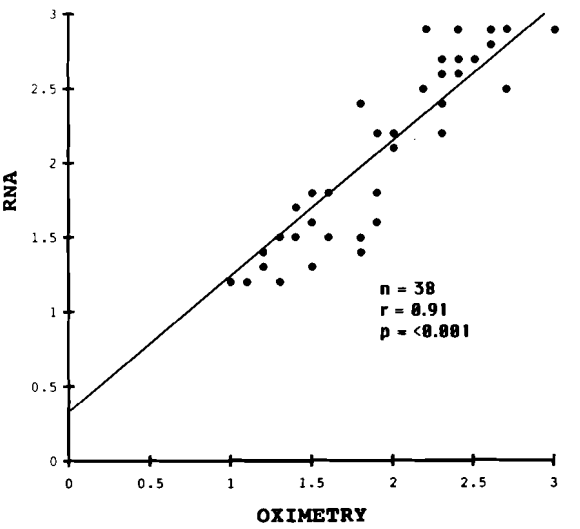

Figure 2: Graph showing correlation of Qp/Qs values of Oximetry and RNA.

Flow ratios measured by two techniques i.e., oximetric and RNA were compared by linear regression analysis.

Results

All the 8 normal results by oximetric method were normal by RNA. All the 30 patients with confirmed L-R shunt oximetrically were positive by RNA with Qp/Qs ratio > 1.2, and with 100% sensitivity (Table 1). Linear regression analysis gave a high and positive correlation with the following values, $r = 0.91$, $p < 0.001$; mean Qp/Qs oximetrically, 1.85 (1.0 to 3.9); and mean Qp/Qs by RNA = 2.03 (1.0 to 3.6) (Figure 2).

Discussion

The quantitative evaluation of L-R cardiac shunt is useful for clinical management. We carried out this study retrospectively to evaluate our technique in comparison with oximetry. Experience is most valuable in obtaining correct and consistent results. Since L-R shunt studies are infrequently performed, our computer program minimizes this difficulty by

Table 2. *Comparison of RNA results with other studies.*

Author	Correlation coefficient (r)
Matlz	0.91
Sward	0.94
Askenazi	0.93
Gelford	0.93
Baker	0.83
KKUH	0.91

automatically obtaining the points that are most adequate and selecting the best fitting curve from various attempts with the option of operator intervention. Our results confirmed the validity of the measured ratio of pulmonary to systemic flow by first passing RNA in patients with L-R shunt. Our results were comparable to the results of the other studies (Table 2).[1,5,6] RNA offers more accurate measurements when the shunt is present at the atrial level,[7] RNA has some limitations ensuring a good bolus injection is very important.[6] There are limitations in automatic gamma variate fitting. The segments of the curves have to be carefully selected. The results are not reliable when there is a bidirectional shunt, shunts between great vessels and when Qp/Qs values are > 3.0. In conclusion, RNA is noninvasive, simple, highly sensitive, takes a very short time and is reliable, which makes it a method of choice for follow-up

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