Effect of Inspiration on Bolus Injection

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Adequate compact intravenous (i.v.) bolus injections of radiopharmaceuticals are essential for many quantitative radionuclide studies. Techniques have been described to obtain optimum bolus injections. The effect of inspiration on i.v. bolus injections was studied in 36 individuals. A slow, deep inspiration just prior to the arrival of the bolus within the superior vena cava significantly improved the quality of the bolus.

The importance of a good compact intravenous (i.v.) bolus during quantitative radionuclide studies has been previously emphasized (*1–3*). Techniques to improve the quality of the bolus include: 1) injection into a catheter in the superior vena cava with a small bolus of radioactive material followed by a saline flush; 2) injection of a small radioactive bolus through tubing into the antecubital vein followed by a large flush of 15–20 cc of saline; or 3) securing a tight tourniquet to distend the venous system followed by a slow injection of a small radioactive bolus and rapid release of the tourniquet (*1–3*). The adverse effect of valsalva on bolus injection has likewise been discussed (*3*). To optimize the technique for good injections, a study of the effect of inspiration on the bolus was undertaken.

MATERIALS AND METHODS

Thirty-six patients referred for gated blood-pool imaging were included in this study. These individuals (23–88 yr old) were divided into two groups. Group 1 and Group 2 comprised 17 individuals (11 men, 6 women) and 19 individuals (16 men, 3 women), respectively. The technique for Group 1 consisted of rapidly injecting [^{99m}Tc]pertechnetate through a 21-gauge needle with a 10-cc normal saline flush through an antecubital vein of an extended arm. The individual was told to relax and breathe normal breaths without stopping, straining, or holding the breath during the injection. Group 2 differed from Group 1 only by including a slow, deep inspiration just prior to the arrival of the radioactive bolus within the superior vena cava. The individuals were again told not to hold their breaths or strain.

The patients were injected with tin pyrophosphate and after a 20-min delay were placed supine with the scintillation camera in the anterior chest projection. Dynamic images were obtained with a standard field-of-view camera fitted with a high sensitivity collimator. Serial images were recorded at 0.25-sec intervals into 64 × 64 byte mode images using a dedicated computer system.* A region of interest was placed over a portion of the superior vena cava and a time-activity curve was generated. Left ventricular ejection fractions were then obtained.

RESULTS

A bolus score (sec) was calculated as the time between the 10% point on the upslope of the superior vena cava curve and the 25% point on the downslope (*4*). The calculations were made by using commercial software included in the computer system. The bolus scores and left ventricular ejection fractions (LVEFs) of each individual are given in Tables 1 and 2. Group 1 and Group 2 had mean bolus scores of 6.07 ± 0.68 sec and 3.81 ± 0.55 sec, respectively. Statistical analysis of the results using an unpaired t-test revealed a statistical difference ($p < 0.01$) between the two sets of numbers.

DISCUSSION

Our study reveals an improvement in the compactness of a radioactive bolus during i.v. injection with inspiration. The rationale for this is that during inspiration there is a decrease in intrathoracic pressure that will aid the movement of a bolus within the blood vessels within the chest (*5,6*). This is the antithesis to the valsalva or deep breath expiration that will raise the intrathoracic pressure hindering the movement of bolus flow (*5,6*). Of course, other factors must be considered in bolus injection such as the rapidity of injection, an adequate antecubital or external jugular vein, and the timing of the inspiration with the arrival of the bolus within the superior vena cava. Analysis of individual results of our patients showed that the bolus score was high in a few of our Group 2 individuals.

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TABLE 1. Bolus Scores and Left Ventricular Ejection Fractions of Group 1 (Without Inspiration)

Patient Age	Sex	Bolus Score (sec)	LVEF (%)
61	M	5.75	16
70	M	4.00	49
74	F	4.75	34
52	M	2.25	62
66	M	9.50	23
64	M	5.00	62
59	M	4.75	52
63	M	9.00	14
64	M	3.50	48
64	M	11.75	35
54	M	8.00	60
65	M	10.75	48
63	F	2.50	61
72	F	5.25	79
37	F	6.00	61
53	F	4.25	72
23	F	6.25	65
Mean	—	6.07	49.5
± SEM	—	0.68	4.6

TABLE 2. Bolus Scores and Left Ventricular Ejection Fractions of Group 2 (Inspiration)

Patient Age	Sex	Bolus Score (sec)	LVEF (%)
67	M	2.00	58
61	M	2.25	34
54	M	7.25	40
60	M	2.00	56
69	M	1.50	45
66	F	1.75	50
53	M	3.00	60
63	M	2.75	51
56	F	4.00	70
38	M	4.00	45
54	M	8.75	14
49	M	3.00	33
58	M	3.25	56
72	F	3.00	55
51	M	1.75	38
55	M	4.50	46
44	M	10.00	53
88	M	3.00	58
23	M	4.75	55
Mean	—	3.81	48.3
± SEM	—	0.55	2.9

This may have been related to poor timing of the inspiration or an unintentional breath hold or valsalva. The same situation arose in a few of our normal-breath group subjects.

The addition of the inspiration during bolus injection is relatively simple, requiring no additional time or devices. The technique must be learned and practiced since timing of the inspiration with bolus arrival to the superior vena cava is important.

In further analysis of our data, when comparing the bolus scores of both groups to the LVEF, we found a suggestion that a low LVEF may additionally worsen the bolus score. These data, however, are preliminary and further investigation of this factor is being done at our institution.

In conclusion, inspiratory intervention during i.v. bolus injection improves the bolus score. Further investigation of a potential adverse effect on the bolus score by low LVEF is needed.

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FOOTNOTES

*MDS A^2, Medtronic Inc., Ann Arbor, MI.

REFERENCES

1. Gray WR, Hickey D, Parkey RW, et al. Quantitative blood pool imaging. In Parkey RW, Bonte FJ, Buja LM, Willerson JT, eds. *Clinical Nuclear Cardiology,* New York: Appleton-Century-Crofts, 1979:298.

2. Treves S, Parker JA. Detection and quantification of intra-cardiac shunts. In Strauss HW, Pitt B, eds. *Cardiovascular Nuclear Medicine,* 2nd ed, St. Louis: CV Mosby, 1979:149-61.

3. Berger HJ, Zaret BL. Cardiac imaging. In Freeman LM, ed. *Freeman and Johnson's Clinical Radionuclide Imaging Vol. 1,* 3rd ed, Orlando: Grune & Stratton, 1984:416-18.

4. Left to right cardiac shunt. In *Spectra Clinical Imaging Systems Operator's Reference Manual,* Medtronic Medical Data Systems, 1983:3-76-3-77.

5. Buda AJ, Pinsky MR, Ingels NB, et al. Effect of intrathoracic pressure on left ventricular performance. *N Engl J Med* 1979;301:453-59.

6. Robotham JL, Scharf SM. Effects of positive and negative pressure ventilation on cardiac performance. *Clinics in Chest Medicine* 1983;4:161-87.