The Q-T Ratio as a Guide to the Exercise Test in the Digitalized Subject

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Ten normal digitalized subjects and six patients with ischemic heart disease taking digitalis were studied to determine the utility of the Q-T ratio as a possible guide to differentiating a positive and negative exercise test in the presence of digitalis. A striking decrease in the Q-T ratio in normal digitalized subjects was seen with exercise. Digitalized patients with ischemic heart disease, however, responded with a uniform lengthening of the Q-T ratio with exercise. Thus, in this small group of patients, it appears that shortening of the Q-T ratio, in the presence of ST segment changes with exercise in the digitalized subject favors a false positive test due to the drug, whereas lengthening of the Q-T ratio favors a truly positive test unrelated to the drug.

It has been known for many years that digitalis will alter the appearance of the resting electrocardiogram. The ST segment will become more or less depressed, in an asymmetrical fashion and the T wave voltage will lower. These changes will depend somewhat on the duration and the dose of digitalis.1-3 Digitalis will also decrease the Q-T interval,4-10 although some workers suggest that this is a transient finding.11

Occasionally, one is confronted with the need to perform exercise electrocardiograms as an aid in diagnosis of ischemic heart disease or to determine work tolerance in the presence of ischemic heart disease in patients already taking digitalis. However, there have been a sufficient number of studies to show that the exercise electrocardiogram may reveal ST segment depressions diagnostic of a positive test in patients taking digitalis but free of clinical ischemic heart disease.12-19 At least one report has suggested that exercise ST-T changes will occur in normal subjects only if the resting electrocardiogram reveals evidence of "digitalis effect."20

Master and Rosenfeld21 reported that prolongation of the Q-T interval with exercise is a common finding in ischemic heart disease. They found that the utilization of the Q-T ratio is diagnostic in most cases, and that a Q-T ratio greater than 1.08 is almost never associated with a false negative response. These studies were performed on non-digitalized patients. Kawai and Hultgren22 studied the effect of potassium on the exercise test after digitalis administration. They indicated that the Q-T ratio was greater than 1.08 in only four of their subjects after exercise, and these all had suspected heart disease.

The purpose of this study was an attempt to answer the question of whether there is any method to distinguish a false positive from a true positive exercise test in persons taking digitalis. We approached the problem by examining the change in the Q-T ratio with exercise as well as its degree of prolongation in normal subjects and in those with ischemic heart disease already taking digitalis.

METHODS AND MATERIALS

Ten normal subjects, seven men and three women ranging in age from 22 to 37 years were studied (Table 1). None had any objective evidence of heart disease, nor any symptoms suggesting angina pectoris. All were subjected to a resting electrocardiogram, and a double Master exercise tolerance test whose criteria have been amply discussed in other reports.20-24 All limb leads and precordial leads V1, V5, and V6 were recorded immediately, two, four, and six minutes after exercise was completed.

These subjects were then instructed to take 2.5 mg of digoxin orally over a 24-hour period and the electrocardiogram was repeated at rest and after exercise. In all subjects in this group, the R/T ratio was recorded in lead I at rest before and after digoxin, and at the two minute post-exercise period before and after digoxin. The Q-T ratio was measured in either lead I or II, whichever demonstrated the T waves with the most obvious termina-

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tion, but in each individual case the same lead was measured throughout.

The Q-T ratio was derived from the formula:

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\text{Corrected Q-T} = \text{Measured Q-T} - 0.4 \sqrt{R-R''}
\]

In addition, all exercise tracings were analyzed for diagnostic ST segment depressions.

Six patients with at least one well-documented old myocardial infarction were also studied. All were taking digoxin 0.25 mg daily because of previous heart failure or supraventricular arrhythmias. All were studied in a manner similar to the normal group except that no predigitalization exercise tests were available. The small number in this group was determined completely by the difficulty that we had in finding patients with well-documented myocardial infarctions who were already taking digitalis. We felt that we were not justified in digitalizing patients with ischemic heart disease in whom no indication for digitalization existed in order to increase the number in this group. As with digitalization, there was also some reluctance to subject patients with healed myocardial infarction to an exercise test in the absence of a clear-cut clinical indication to do so. However, this reluctance was of a lesser magnitude, since all the patients studied had already returned to their full-time occupations, and in every case were probably engaging in at least as much activity as that imposed by an exercise test. In addition, it has been our practice to perform exercise tests in patients after myocardial infarction in order to ascertain their work tolerance.

All tracings were taken with a Cambridge electrocardiograph apparatus.

The criteria for a positive exercise test were those of Master,31 namely any ST segment depression of 2 mm or more, an ischemic ST-T depression (covering or completely horizontal ST) of any degree, a QX/QT ratio of over 50 per cent or a Q-T ratio over 1.06.

RESULTS

The results are tabulated in Table 1 for the normal subjects, and in Table 2 for those with ischemic heart disease.

All of the normal subjects developed minor ST-T changes at rest, after taking digoxin. None developed a positive exercise test before or after taking digoxin, although increases in the non-diagnostic ST-T changes seen prior to exercise appeared after effort in several of them. In three cases (K. B., J. B., and S. M.) the R/T ratio became larger with exercise before digoxin. This alteration in the R/T ratio persisted after digoxin in all three. Of greatest interest is the decrease in Q-T ratio in each subject after exercise before digoxin, and the same results after digoxin except in one case, M. H., in which the Q-T ratio increased. Thus the small number of normal subjects studied here appear to react to exercise with a shortening of the Q-T ratio with or without digoxin.

The findings in patients with ischemic heart disease are summarized in Table 2. Four patients developed an increase in the R/T ratio with exercise. All patients developed a lengthening of the Q-T ratio with exercise. One subject (L. D.) performed exercise without the development of an overtly positive test, but the Q-T ratio increased to 1.09.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>R/T (Digoxin)</th>
<th>Q-T Ratio (Digoxin)</th>
<th>Resting ECG</th>
<th>Effects of Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. B.</td>
<td>54</td>
<td>F</td>
<td>3.0</td>
<td>4.5</td>
<td>.95</td>
<td>1.00</td>
</tr>
<tr>
<td>I. B.</td>
<td>43</td>
<td>F</td>
<td>4.0</td>
<td>4.0</td>
<td>1.07</td>
<td>1.13</td>
</tr>
<tr>
<td>H. S.</td>
<td>64</td>
<td>M</td>
<td>6.0</td>
<td>2.5</td>
<td>.99</td>
<td>1.05</td>
</tr>
<tr>
<td>S. B.</td>
<td>52</td>
<td>M</td>
<td>4.0</td>
<td>4.25</td>
<td>.92</td>
<td>1.06</td>
</tr>
<tr>
<td>W. B.</td>
<td>62</td>
<td>M</td>
<td>3.0</td>
<td>5.0</td>
<td>.98</td>
<td>1.00</td>
</tr>
<tr>
<td>L. D.</td>
<td>59</td>
<td>M</td>
<td>2.0</td>
<td>2.75</td>
<td>1.03</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Q-T RATIO AS GUIDE TO EXERCISE TEST

DISCUSSION AND CONCLUSIONS

It is well recognized by us that the measurement of the Q-T interval is often extraordinarily difficult to perform because of doubt concerning the point at which the T wave ends. This has been documented frequently. However, in this study, all of our normal subjects demonstrated well-defined Q-T intervals. Fortunately, this was also true of our patients with ischemic heart disease. In this admittedly small series, there appeared to be a uniform decrease in the Q-T ratio in normal patients after exercise whether digitalized or not. In contrast, the digitalized patients with ischemic heart disease respond in every case with a uniform lengthening of the Q-T ratio after exercise. The Q-T ratio did not lengthen beyond 1.05 in every instance, suggesting that the absolute value of the Q-T ratio may be less important than the fact that the Q-T ratio lengthens.

We emphasize that firm conclusions cannot be based on a series as small as this. The necessity for small numbers in the patient group, as previously stated, was dictated by our unwillingness to administer digitalis to patients with ischemic heart disease in whom no indication for its use existed. Nevertheless, the surprisingly uniform change in the Q-T ratio in totally opposite directions when the normal and patient groups were compared and contrasted prompted us to report our findings at this time, rather than to await the acquisition of further subjects in the patient group.

REFERENCES


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