Coarctation in the Elderly

By M. V. Brainbridge, F.R.C.S., and A. Yen, M.R.C.P., F.R.C.S.

RESECTION of a coarctation in the elderly patient carries a significant mortality. The age at which it has been said that the risks of surgery outweigh the regression of blood pressure has risen over the years from 25 in 1953, to 34 in 1957 and is about 40 at the present time, though some believe that there should be no upper age limit.1-3

The present study was undertaken to balance the risks of surgery against postoperative improvement and to compare the clinical presentation of the older patient with a representative group of all ages.

Material

The elderly series consisted of 31 patients, and included every patient whose coarctation had been resected over the age of 40 in the undergraduate and postgraduate teaching hospitals of London before March 1963. The ages varied from 40 to 57, with an average of 46 years.

The larger group of all ages consisted of 119 patients operated upon at the Brompton Hospital between 1950 and 1962.4 The ages varied from 3 to 56, with an average of 22 years.

Clinical Presentation

Symptoms

The symptoms of coarctation of the aorta are due to proximal hypertension (left ventricular strain and cerebral hypertension), turbulence at bicuspid aortic valve and isthmus (subacute bacterial endarteritis), and poor peripheral circulation (intermittent claudication, cold feet, and cramp at rest).

Long-standing proximal hypertension increased the incidence of left ventricular strain in the older patients to 80 per cent compared with 44 per cent in the over-all group of coarctations (fig. 1). Dyspnea on exertion was the dominant symptom (68 per cent) but palpitations and angina were also prominent. Ac-

Figure 1

Symptoms of patients in elderly and over-all groups compared (over-all group in italics.)

The incidence of cerebrovascular accidents was increased from 4 to 10 per cent in the older group.

There was no elderly patient with a history of subacute bacterial infection compared with 4 per cent in the series of all ages. Poor peripheral circulation gave rise to a relatively slight increase in symptoms. Intermittent claudication, cold feet, and cramp at rest were encountered in 26 per cent compared with 18 per cent in the younger group.

In spite of their age, 48 per cent of the older patients were still diagnosed at chance examinations and 13 per cent were asymptomatic even on direct questioning, compared with 66 per cent and 34 per cent in the over-all group.

Physical Signs

Comparison of the physical signs of the elderly series with those of the over-all group is shown in figure 2. Fewer, surprisingly, were

From the Surgical Unit, St. Thomas’s Hospital Medical School and Hospitals for Diseases of the Chest (Brompton and London Chest Hospitals), London, England.
B.P. Rt. Arm 206/100 172/98
Lt. Arm 197/100 167/98

FEMORAL PULSE 1 and DELAYED 100 99
60% 97% 62% 78% 45%

"COARCTATION" MURMUR 81 52
E.C.G. L.V. + 90 59
CHEST X-RAY: L.V. + 94 73
Rib noting 100 85
Coarctation visible 84 85

Figure 2

Physical signs of elderly and over-all groups compared (over-all group in italics).

recorded as having palpable collateral vessels around the shoulder girdle (78 per cent compared with 97 per cent) for which there was no obvious explanation. All but one were in sinus rhythm in both groups.

The average blood pressure in the right arm was 206/100 mm. Hg in the older group, compared with 172/98 in the young group, and 197/100 mm. Hg in the left arm, compared with 167/98. The normal blood pressure, however, for a man of 46 is 130/80 mm. Hg, and for a woman 133/81 mm. Hg; the equivalent pressures at the age of 22 are 121/74 and 120/72 mm. Hg.5 The average level above normal was then approximately 70/20 mm. Hg in the elderly, compared with 50/25 mm. Hg in the younger group. The femoral pulse was invariably diminished and delayed in the older group, which correlated with an average coarctation lumen of 2 mm.

On auscultation, the presence or absence of ejection clicks and mitral diastolic murmurs was not adequately recorded in early cases and a comparison of their over-all incidence

was not possible. Ejection murmurs were almost invariably heard (97 compared with 87 per cent) but the second sound was less often normal (62 compared with 78 per cent), a prolonged left ventricular ejection time increasing the incidence of single second sounds (25 per cent) and reversed splits (13 per cent). Coarctation murmurs were less often heard posteriorly, due partly to the seven coarctations with no lumen. Left ventricular hypertrophy was more frequently present electrocardiographically (90 compared with 59 per cent) and on the chest radiograph (94 compared with 73 per cent). Rib notching was invariably present in the older group but the coarctation was no more often visible (84 per cent).

Angiography was used to delineate the anatomy in 39 per cent. In the light of modern knowledge it was unnecessary in all but one lower thoracic case as the presence and situation of the coarctation were obvious from physical signs and radiologic examination.

Associated Anomalies

Associated shunts were rather fewer in the older group (3 per cent with persistent ductus arteriosus and none with ventricular septal defect, compared with 6 and 1 per cent, respectively, in the large series) (fig. 3). Coincident valve defects were fewer, dropping from 21 to 12 per cent. Significant aortic incompetence was still the commonest (6 per cent). An additional 13 per cent had aortic diastolic

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murmurs. Mitral incompetence was less common (3 per cent compared with 7 per cent).

Operative Findings and Techniques

Almost all (94 and 95 per cent) of the coarctations of both groups were typical, the isthmus being immediately distal to a normally arising left subclavian artery. Three per cent of the elderly group and 2 per cent of the younger group were at unusual sites, one in the lower thorax in each group, and another in the abdomen in the over-all group. One subclavian artery (3 per cent) in the elderly and four subclavian arteries (3 per cent) in the over-all group arose distal to the isthmus.

The lumen of the coarctation of both groups was, on the average, 2 mm. The lumen size was recorded in 21 patients in the elderly group—in seven (33 per cent) there was no lumen, in nine (43 per cent) it was between 1 and 2 mm., and in five (24 per cent) it was 3 or more mm. A “coarctation” murmur had previously been heard posteriorly in four of the seven patients with no lumen, while it was absent in three.

Aneurysms were more common in the elderly group (42 compared with 23 per cent) the increased incidence being entirely due to intercostal aneurysms (39 per cent compared with 18 per cent) (fig. 4). There was no proximal and only one distal aneurysm in this group.

Operative Procedure

One of the elderly patients (3 per cent)

GRAFTS 16% 18%

1. TYPE
   - FREEZE-DRIED HOMOGRAFTS 10 14.5
   - TEFILON 6 2.5
   - IVALON 0 1

2. REASON FOR INSERTION
   - LONG NARROW SEGMENT 3 9
   - ANEURYSM 3 4.5
   - POOR NEIGHBOURING TISSUE 10 13.5
   - BYPASS for ABDOMINAL COARCTn. 0 1

3. MORTALITY
   - ALL GRAFTS 6 3
   - DUE DIRECTLY to GRAFT 0 1

Figure 5
Insertion of grafts (over-all group in italics).

died of hemorrhage and cardiac arrest during resection of the aorta. An end-to-end anastomosis was possible in 81 per cent (82 per cent in the over-all series). Grafts were required as frequently in each group (16 and 18 per cent). Homografts (10 per cent) and Teflon (6 per cent) were used (fig. 5). The dominant reason for insertion of the grafts changed from a long narrow segment (9 per cent of the group of all ages) to the presence of neighboring tissue too poor to hold sutures in the elderly series (10 per cent). Aneurysms necessitated grafting in 3 per cent (4.5 per cent in the main group).

The mortality of the patients in whom grafts were inserted doubled in the older group (6 compared with 3 per cent). The lumen achieved after resection was universally satisfactory in the elderly series. One anastomosis was 80 per cent of the proximal aortic diameter and the remainder 90 per cent or more.

Results of Operation

Mortality

Operative mortality doubled in the elderly group (13 compared with 6 per cent) (fig. 6).
All four deaths were due to hemorrhage from the aorta—one during dissection, two in the immediate postoperative period, and one after administration of heparin during dialysis for renal failure. The over-all group’s mortality had been due to hemorrhage in two, false and mycotic aneurysm formation in three, unskilled use of hypotensive drugs in one, and renal failure in one.

Late deaths were two (6 per cent) in the elderly group, one dropping dead abroad 3 years later, no autopsy being performed, and another at a subsequent extracorporeal circulation operation for calcific aortic stenosis. Two of the over-all group had dropped dead (no autopsy), one had died of cerebral thrombosis, and two had died at subsequent bypass operations (4 per cent). The total mortality was therefore 19 per cent in the elderly group, compared with 10 per cent in the main group.

Morbidity

The incidence of complications in the 27 operative survivors was higher in the elderly group (41 compared with 31 per cent) (fig. 7). General thoracic complications—pneumonia, atelectasis, pneumothorax, pleural effusions, and wound infections—accounted for almost all the morbidity (30 per cent). Seven per cent had troublesome postoperative hypertensive episodes—persistent hypertension above the preoperative level—and one patient (4 per cent) had thrombophlebitis. The commonest postoperative complications of the

<table>
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<th>Complication</th>
<th>No.</th>
<th>%</th>
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<tr>
<td>Haemorrhage</td>
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<td>2-5</td>
</tr>
<tr>
<td>Hypertensive episodes</td>
<td>7 ₁₃</td>
<td></td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>0  3-₅</td>
<td></td>
</tr>
<tr>
<td>S.B.E. (non-fatal)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Thoracic</td>
<td>3₀  5</td>
<td></td>
</tr>
<tr>
<td>Neurological</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Thrombophlebitis</td>
<td>4  1</td>
<td>4₁   3/₇</td>
</tr>
</tbody>
</table>

**Figure 7**

Comparison of morbidity rates (over-all group in italics).

over-all group were hypertensive episodes (13 per cent). Hemorrhage, abdominal pain, subacute bacterial endocarditis, thoracic complications, nerve palsies and thrombophlebitis made up the remainder.

One of the older patients, who subsequently died of aortic hemorrhage during dialysis, developed renal failure. His aorta had been occluded for 3½ hours as attempts at anastomoses failed due to poor adjoining tissue.

**Postoperative Improvement**

**Symptoms**

Eighteen (72 per cent) of the 25 survivors in the elderly group were asymptomatic compared with only 13 per cent before operation. Seven patients (28 per cent) still had some symptoms (there were three complaints of headache, two of giddiness, and one each of palpitations, angina, dyspnea, chillblains, and thoracotomy pain).

**Blood Pressure**

Six patients died, leaving 25 patients in whom the blood pressure was taken in both
The average blood pressure for the elderly group before operation was 206/100 in the right arm and 197/100 in the left. On discharge from the hospital it was 155/91 in the right arm, and at follow-up examination, at a mean of 2.8 years later (variation 2 months to 7 years), it was 155/93 (fig. 8). The equivalent figures for the larger group were 172/98, 167/98, 139/83, and 139/82. Relation of the mean pressures to normal showed a greater similarity between the groups (fig. 9). The systolic and diastolic pressures of the older group were initially 70/20 mm. Hg above normal (50/25 mm. Hg in the over-all group) falling to 21/11 mm. Hg (29/10 mm.) on discharge from hospital, and 16/11 mm. Hg (16/8 mm.) above normal at follow-up.

Average figures are relatively meaningless due to the different age ranges covered; so the individual blood pressures before operation and at follow-up were therefore plotted against the normal pressures expected for the age and sex of the patient\(^5\) (figs. 10-13).

The distribution of systolic and diastolic...
pressures in the right arm before and after operation have been compared with one absolute and three relative pressures (fig. 14). Before operation 48 per cent of systolic blood pressures of the elderly were under 200 mm. Hg, compared with 93 per cent in the main group. Twelve per cent of the elderly and 27 per cent of the over-all group fell within 40 mm. Hg of the normal mean level for age and sex, 8 per cent (4 per cent) within 21 mm. Hg and none in either group was at or below the normal mean level.

After operation all systolic pressures were under 200 mm. Hg. Relation to normal showed the pressures of both groups to be remarkably similar. Ninety-two per cent (85 per cent) were within 40 mm. Hg of normal for age and sex, 60 per cent (57 per cent) within 20 mm. Hg, and 24 per cent (23 per cent) at or below the normal line.

The diastolic pressures before operation were similarly compared. Fifty-six per cent of the elderly group were less than 110 mm. Hg, compared with 74 per cent in the over-all group. Fifty-two per cent (26 per cent) were within 20 mm. Hg of the normal mean, 32 per cent (16 per cent) within 10 mm. Hg, and 12 per cent (3 per cent) were at or below the normal line.

After operation the diastolic pressures of the two groups were again remarkably similar. Eighty-eight per cent (96 per cent) were under 110 mm. Hg, 84 per cent (86 per cent) were within 20 mm. Hg of the normal mean, 60 per cent (54 per cent) within 10 mm., and 20 per cent (17 per cent) at or below the normal line.

**Chest Radiograph**

Radiologically there was not much change. Because the cardiothoracic ratio is a notoriously inaccurate method of cardiac measurement, transverse diameters of the heart have been used as a somewhat more accurate and comprehensible measurement.²

Twenty-four patients had chest radiographs
available for comparison before operation and at follow-up, at a mean of 2.8 years later. The transverse cardiac diameters of five (21 per cent) were unchanged, three (12 per cent) were larger by an average of 1 cm., and 16 (67 per cent) were smaller by an average of 1.4 cm. The over-all average change was a diminution in size by 0.6 cm.

**Discussion**

Coarctation has been described in patients up to the age of 92, but the average age at death is about 33 years. Operations on patients above the age of 40 are uncommon, reflected by the fact that only 31 have been collected from the entire experience of the thoracic surgeons at London's undergraduate and postgraduate teaching hospitals. The incidence from the literature varies from 13 per cent to none. Eight per cent of those patients who were operated on at the Brompton Hospital up to 1962 were aged over 40.

Deaths due directly to coarctation result from rupture of the aorta, subacute bacterial endocarditis, left ventricular failure, or cerebrovascular accidents, and the symptoms of patients who have had a coarctation for 40 years should reflect the imminence of these complications. In this series there was of course no patient with a history of aortic rupture. None either had had subacute bacterial endarteritis, which must have proved lethal or demanded earlier operation.

The incidence of symptoms due to left ventricular strain in the elderly group was double the incidence in the larger group of all ages. Left ventricular failure itself increased six-fold. Cerebral symptoms were twice as common in the older group, but those due to a decreased blood flow to the lower limbs were only slightly more frequent presumably due to the good collateral supply that must have developed over the years.

Even after the age of 40 a coarctation may still be recognized by chance. The diagnosis was made at incidental examinations in almost half the cases. One eighth were still asymptomatic on direct questioning, com-

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### Table: Preoperative and Postoperative Blood Pressures

<table>
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<th>Category</th>
<th>Pre-op (%)</th>
<th>Post-op (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNDER 200 mm. Hg</strong></td>
<td>48 93</td>
<td>100 100</td>
</tr>
<tr>
<td><strong>WITHIN 40 mm. Hg of normal mean</strong></td>
<td>12 27</td>
<td>92 85</td>
</tr>
<tr>
<td><strong>WITHIN 20 mm. Hg of normal mean</strong></td>
<td>8 4</td>
<td>60 57</td>
</tr>
<tr>
<td><strong>AT or BELOW normal mean</strong></td>
<td>0 0</td>
<td>24 23</td>
</tr>
<tr>
<td><strong>UNDER 110 mm. Hg</strong></td>
<td>56 74</td>
<td>88 96</td>
</tr>
<tr>
<td><strong>WITHIN 20 mm. Hg of normal mean</strong></td>
<td>52 26</td>
<td>84 86</td>
</tr>
<tr>
<td><strong>WITHIN 10 mm. Hg of normal mean</strong></td>
<td>32 16</td>
<td>60 54</td>
</tr>
<tr>
<td><strong>AT or BELOW normal mean</strong></td>
<td>12 3</td>
<td>20 17</td>
</tr>
</tbody>
</table>

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*Figure 13*

**Elderly group, ages and blood pressures as at follow-up.**

*Figure 14*

**Analysis of preoperative and postoperative systolic blood pressures (top) and diastolic pressures (bottom). Over-all group in italics.**

*Circulation, Volume XXXI, February 1965*
pared with a third of the over-all group and two thirds of Wood's series.11

The physical signs of an elderly coarctation should show the effects of long-standing hypertension, although the blood pressure in coarctation does not increase in a linear fashion with age but tends to level out during the third decade.12 When related to the normal mean pressure for the age of the patients, the systolic pressure was only 20 mm. Hg higher and the diastolic pressure actually 5 mm. Hg lower than the large group, reflecting the presence of aortic incompetence in one fifth of the patients. The effect of the long-standing load on the left ventricle was more obvious. The prolonged left ventricular ejection time led to a decreased number of patients with a normal second sound at the base. There was electrocardiographic evidence of left ventricular hypertrophy and some radiographic enlargement in almost all the older patients. Good collateral circulation produced rib notching in all, but the aortic knuckle was not always abnormal even after 40.

The coarctation of a patient surviving to 40 or more might be expected to be relatively mild but the femoral pulse in this series was uniformly found to be diminished and delayed and the coarctation lumen was on average the same as that for the larger group. In a third there was in fact no lumen at all. A "coarctation" murmur was recorded posteriorly in over half of these, for which the explanation is obscure, if the assumption is correct that the murmur is due to flow through the stenotic area.11

Skandalakis and associates13 implied that aneurysms associated with coarctation were usually aortic (83 per cent) and seldom intercostal (10 per cent), a relative incidence that did not hold for either of these series or that of Schuster and Gross.8 Aneurysms were more common in the elderly group than in the younger, solely because of the number of intercostal aneurysms. The distinction between "large," "aneurysmal," and "aneurysm of" an intercostal artery is fine and may account in part for this increase in a retrospective study. Aortic rupture in coarctation in any case occurs from proximal dissection more often than rupture of an aneurysm11 and the increased incidence may have been less hazardous than superficially it seems.

After resection of the coarctation an end-to-end anastomosis was usually possible and the lumen achieved was satisfactory in all instances. Grafts were required in one sixth of the patients in both groups, but for different reasons. In the older patient a graft was necessary, primarily because of poor anastomotic aortic tissue and only rarely for a long narrow segment, while the latter was the prime reason for a graft insertion in the large series. Cystic medial necrosis is a recognized complication of coarctation, and atherosclerosis may occur earlier in the presence of proximal hypertension and make the elderly aorta more friable.

The operative mortality of coarctation resection can be as low as 1.6 per cent if older patients and those with associated cardiac defects are avoided.8 Operation over the age of 40 carries a higher risk, which varies from 7 to 37 per cent in the literature.3, 14 The operative mortality of the older series reported here was double that of the larger group. Aortic hemorrhage was the sole cause of death, again stressing the friable nature of the aorta of the elderly patient with coarctation. Late deaths from subsequent bypass operations and unexplained collapse were in much the same ratio in both groups.

Morbidity following operation for coarctation can be as low as 4 per cent.8 It was much higher following resection of the elderly coarctations, mainly due to pulmonary and pleural complications, as might be expected in a community living in London with its tendency to chronic bronchitis and emphysema.

The increased mortality and morbidity of operation on patients over 40 can only be justified if the blood pressure is lowered and the patient improved symptomatically, electrocardiographically, and radiologically.

Figures for blood pressure are relatively meaningless unless they are related to the normal for the age and sex of the patient.5 Before operation the systolic pressures of only

* Circulation, Volume XXXI, February 1965
one eighth of the elderly patients were within 40 mm. Hg and one twelfth within 20 mm. Hg of the expected mean for age and sex of the patient. At follow-up examination nine tenths and three fifths were within these limits. Preoperative diastolic pressures were within 20 mm. Hg of normal in half and 10 mm. Hg in a third of the patients. After operation five sixths and three fifths of the pressures fell into these categories.

In the younger group before operation the relative systolic pressures were lower and diastolic pressures higher than in the older group. At follow-up examination, however, the pressures of both groups bore a remarkable similarity of distribution.

The return toward normality in these two series was less striking than in the 12 surviving patients over 40 reported by Oey and Noordijk.14 Before operation their systolic pressures were lower and diastolic pressures higher than in this series (almost half the preoperative pressures were within 40 mm. Hg systolic and two fifths within 20 mm. Hg diastolic of the normal mean). After operation five sixths had pressures within 20 mm. Hg systolic and nine tenths within 10 mm. Hg diastolic of the normal for the age of the patient.

Symptomatically also the older patients were improved. Three quarters were entirely asymptomatic after operation compared with only one eighth before. Electrocardiographic improvement could not be assessed because of inadequate records, but those available showed either no improvement or at the most one grade of diminution of left ventricular hypertrophy, which is in keeping with the similar finding of Oey and Noordijk.

Radiographic improvement also was not striking. The over-all change was a moderate diminution in size but one fifth were unchanged and one eighth actually larger, due partly to the fact that the hearts of patients with coarctation are seldom much enlarged and partly to persistent aortic incompetence.

Excision of a coarctation in a patient over the age of 40 may therefore be expected to result in a satisfactory regression of hyperten-

sion at least as good as that following resection in a young patient, and in considerable symptomatic though rather less radiologic improvement. The increased mortality and morbidity are acceptable, because the patient has already exceeded his life expectancy without operation and because the incidence of premonitory symptoms of serious complications is rising sharply. Mortality and morbidity could be lowered if care were taken to cut back the aorta to good stitch-holding tissue, and pulmonary complications avoided by vigorous physiotherapeutic measures before and after surgery.

Summary

The clinical presentation and operative results have been assessed of a series of patients with coarctation over the age of 40, and have been compared with a larger group of all ages.

Long-standing hypertension increased markedly the incidence of symptoms due to left ventricular strain and cerebral hypertension. There was little increase in symptoms due to poor peripheral blood flow and no case of subacute bacterial endarteritis.

The preoperative systolic blood pressures, when related to the normal for the age and sex of the patient, were higher and the diastolic pressures lower than an average group but signs of left ventricular strain were more common.

At operation the aortic narrowing was found to be of usual severity. Grafts were necessary because of poor anastomotic tissue rather than long narrow segments as in the larger group. The operative mortality was doubled in the elderly, due entirely to hemorrhage from friable aortas. Morbidity was increased as a result of pulmonary and pleural complications.

Postoperative blood pressures were almost exactly comparable with those of the over-all group when related to normal for age and sex. Symptoms were usually relieved but there was relatively slight radiologic or electrocardiographic change. The operative mortality and morbidity are acceptable in view of the risks of inaction and the satisfactory results of operation in the survivors.

Circulation, Volume XXXI, February 1965
Acknowledgment

I am greatly indebted to Sir Russell Brock, Sir Thomas Holmes Sellors, Mr. L. L. Bromley, Mr. W. P. Cleland, Mr. C. E. Drew, Mr. M. Paneth, and Mr. O. S. Tubbs for permission to report so many of their cases.

References

De Minimis

The law does not concern itself with very small matters—de minimis non curat lex. If this aphorism gives an authentic glimpse of the legal mind, it tells us also that that enigmatic organ differs sharply in at least one particular from the mind of science. For it is characteristic of science not to value things by their size or according to their apparent importance in the eye of common sense. The scientific world is a democracy of facts where the inhabitants are of equal standing and there is no table of precedence. Indeed, the progress of knowledge has been in great part the discovery of the importance of small things and the exaltation of the insignificant. The great development of the medical sciences in the last sixty years has got most of its strength from such a continued revelation of the minute. At its beginning was the demonstration of the meaning of bacteria in disease, about its middle the discovery of the vitamins, in its recent stages the study of the viruses. All these have been concerned with things or substances of which the effective action has been in spite of sizes or amounts excessively small.—The Collected Papers of Wilfred Trotter, F.R.S. London, Oxford University Press, 1946, p. 129.
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_Circulation_. 1965;31:209-218
doi: 10.1161/01.CIR.31.2.209

_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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