CONCLUSION

Birthweight standards evidently vary with ethnic or cultural characteristics as well as with maternal height, weight, and parity and the sex of the baby. All such physiological factors need to be considered when assessing an individual birth weight, and we have therefore refrained from producing charts which can include only some of these variables, such as sex and parity. This can be done by calculating a customised birthweight centile in reference to a normal range which is adjusted by computer for each pregnancy to allow for non-pathological variation.[8] Alternatively, birthweight can be expressed as an individualised birthweight ratio—that is, the ratio of actual to expected weight calculated for each baby.[9] A generalised standard of weight for gestational age has limited application in assessing individual birth weight. As a descriptive population standard, it is meaningful only if it includes details of the heterogeneity of the sample.

1 Thomson AM, Billewicz WZ, Hytten FE. The assessment of fetal growth. *Journal of Obstetrics and Gynaecology of the British Commonwealth* 1968;75: 903-16.
2 Car-Hill R, Pritchard C. *The derivation and exploitation of birthweight standards.* London: Macmillan, 1985.
3 Yudkin PL, Aboualfa M, Eyre JA, Redman CWG, Wilkinson AR. New birthweight and head circumference centiles for gestational ages 24 to 42 weeks. *Early Hum Dev* 1987;15:45-52.
4 Campbell S, Warsof SL, Little D, Cooper DJ. Routine ultrasound screening for the prediction of gestational age. *Obstet Gynecol* 1985;65:613-20.
5 Hall MH, Carr-Hill RA. The significance of uncertain gestation for obstetric outcome. *Br J Obstet Gynaecol* 1985;92:452-60.
6 Geirrson RT, Busby-Earle RMC. Certain dates may not provide a reliable estimate of gestational age. *Br J Obstet Gynaecol* 1991;98:108-9.
7 Grundy MFB, Newman GB. Birthweight standards in a community of mixed racial origin. *Br J Obstet Gynaecol* 1978;85:481-6.
8 Gardosi J, Chang A, Kalyan B, Sahota D, Symonds EM. Customised antenatal growth charts. *Lancet* 1992;339:283-7.
9 Wilcox MA, Johnson IR, Maynard PV, Smith SJ, Chilvers CED. The individualised birthweight ratio: a more logical outcome measure of pregnancy than birthweight alone. *Br J Obstet Gynaecol* 1993;100:342-7.
10 Campbell S, Trickey N, Whittle M. *Report of the RCOG Working Party on Routine Ultrasound Examination in Pregnancy.* London: Chameleon, 1984.
11 Campbell S. Growth of fetal biparietal diameter during normal pregnancy. *Br J Obstet Gynaecol* 1971;78:513-9.
12 Robinson HP, Fleming JEE. A critical evaluation of sonar "crown-rump length" measurements. *Br J Obstet Gynaecol* 1975;82:702-10.
13 SPSS Incorporated. *Statistical package for the social sciences PC+.* Chicago: SPSS, 1988.
14 Hall MH. Definitions used in relation to gestational age. *Pediatric and Perinatal Epidemiology* 1990;4:123-8.
15 Geirrson RT. Ultrasound instead of last menstrual period as the basis of gestational age assignment. *Ultrasound in Obstetrics and Gynecology* 1991;1: 212-9.
16 Lubchenco LO, Hansman C, Dressler M, Boyd E. Intrauterine growth as estimated from liveborn birth-weight data at 24 to 42 weeks of gestation. *Pediatrics* 1963;32:793-800.
17 Roemer VM, Buehler K, Kieback DG. Gestationszeit und Geburtsgewicht. 1. Mittelung: Intrauterine Wachstumskurven. *Z Geburtshilfe Perinatol* 1990; 194:241-53.
18 Chamberlain R, Chamberlain G, Howlett B, Claireaux A. *British births 1970.* Vol I. London: Heineman, 1975:48-88.
19 Persson PH, Kullander S. Long-term experience of general ultrasound screening in pregnancy. *Am J Obstet Gynecol* 1983;146:942-7.
20 Waldenstroem U, Axelson O, Nilsson S. A comparison of the ability of a sonographically measured biparietal diameter and the last menstrual period to preduct the spontaneous onset of labour. *Obstet Gynecol* 1990;76:336-8.
21 Persson P-H. Fetal growth curves. In: Sharp F, Fraser RB, Milner RDG, eds. *Fetal growth: proceedings of the 20th study group of the Royal College of Obstetricians and Gynaecologists.* London: RCOG, 1989:13-25.
22 Weiner CP, Sabbagha RE, Vaisrub N, Depp R. A hypothetical model suggesting suboptimal intrauterine growth in infants delivered preterm. *Obstet Gynecol* 1985;65:323-6.
23 Anderson HR, Bland JM, Peacock JL. The effects of smoking on fetal growth. In: *Proceedings of symposium on effects of smoking on the fetus, neonate and child.* London: Independent Scientific Committee on Smoking and Health, Ciba Foundation, 1990.

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Gastric cancer: a curable disease in Britain

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Abstract

***Objective*—To determine whether more vigorous efforts aimed at earlier diagnosis allied to radical surgical resection lead to improved survival of patients with gastric cancer.**

***Design*—Prospective audit of all cases of gastric cancer treated during 1970-89.**

***Setting*—Department of surgery, general hospital.**

***Subjects*—493 consecutive patients with gastric adenocarcinoma.**

***Main outcome measures*—Operative mortality, postoperative morbidity, and five year survival after radical potentially curative resection.**

***Results*—207 (42%) patients underwent potentially curative resection. The proportion of all patients in whom this was possible increased significantly ($p < 0{\cdot}01$) from 31% in the first five year period to 53% in the last five year period. The proportion of patients who had early gastric cancer rose from 1% to 15% ($p < 0{\cdot}01$) and stage I disease rose from 4% to 26% ($p < 0{\cdot}001$). After potentially curative resection, mortality 30 days after operation was 6%. Operative mortality decreased from 9% in the 1970s to 5% in the 1980s. Likewise, the incidence of serious postoperative complications decreased from 33% in the 1970s to 17% in the 1980s ($p < 0{\cdot}01$). Five year survival was 60% in patients who underwent curative resection, 98% in patients with early gastric cancer, and 93%, 69%, and 28% in stage I, II, and III disease respectively. By the late 1980s five year survival after operation was about 70%.**

***Conclusions*—These findings suggest that an increasing proportion of patients with gastric cancer could be diagnosed at a relatively early pathological stage when about two thirds are curable by means of radical surgery.**

Introduction

Gastric cancer is the fourth commonest cause of death from cancer in the United Kingdom, after cancer of the bronchus, colon and rectum, and breast, and still accounts for about 10 000 deaths each year.[1] In Britain, as in much of the West, the results of treatment of gastric cancer have always been poor[2-5] and even in recent years have shown little sign of improvement.[6,7] Thus, in a large population based study from the west Midlands Allum *et al* found that five year survival for all patients with gastric cancer was 5%, and even after potentially curative resection it was only 20%.[7] Moreover, these authors found that the stage of disease was usually advanced at the time of diagnosis and had not changed much throughout the 25 year period of review. From 1957 to 1981 fewer than 1% of patients presented with stage I disease, and curative resection was possible in only 20-25% of patients. Operative mortality was 16% after potentially curative resection and 25% after palliative resection. Not surprisingly, therefore, a diagnosis of gastric cancer in Britain has come to be regarded by doctors and patients alike as virtually a sentence of death.

In Japan, by contrast, the results of treatment of gastric cancer are much better: more than half the patients have stage I disease at presentation, operative mortality is only 1-3%, and five year survival after curative resection is over 60%.[8,9] Furthermore, Japanese results are improving; patients treated in the

1980s faring considerably better than those treated in the 1970s.[8]

During the 1980s, however, the management of patients with gastric cancer in Britain has changed in several ways. More widespread use of endoscopy has led to earlier diagnosis, at least in some centres[10-12]; more radical surgical techniques have been introduced; and anaesthesia, perioperative care, and nutritional support have all improved. Whether these changes have resulted in any improvement in the outcome for patients with gastric cancer in Britain is as yet unknown. We analysed our experience of almost 500 cases of gastric cancer treated over the 20 years from 1970 to 1989.

Patients and methods

Between 1970 and 1989, 493 consecutive patients with adenocarcinoma of the stomach were treated in the university department of surgery at this hospital. Potentially curative resection was possible in only 207 of them (42%), the definition of potentially curative resection being that all visible tumour was removed and that the proximal and distal margins of resection were free of tumour on microscopic examination. Of the 207 patients, 145 were men and 62 women. Their median (range) age was 68 (23-88) years. Only two patients were under 40 years of age and 14 were under 50.

SURGICAL TREATMENT

Of the 207 potentially curative resections performed, 135 were carried out by consultants, 66 by lecturers or senior registrars, and six by registrars. There were 95 total gastrectomies, 100 subtotal gastrectomies, and 12 oesophagogastrectomies. Since the late 1970s our policy has been to perform wide gastric resection with radical (R2) lymphadenectomy, in which the second tier of lymph nodes (N2) beyond the perigastric nodes (N1) is removed.[13] In a few cases, this radical type of surgery was modified because of the patient's advanced age or the presence of serious associated disease. All total gastrectomies and 24 of the subtotal gastrectomies were completed by Roux-en-Y reconstruction whereas most (76) of the subtotal gastrectomies were of the Polya variety.

PATHOLOGICAL STAGING

All tumours were staged in accordance with the 1987 Unified International tumour, node, metastases (TNM) classification of gastric cancer (table I).[14] Early gastric cancer was defined as tumour confined to the mucosa or submucosa (T1) irrespective of lymph node involvement.[15] Of the 207 patients who underwent potentially curative resection, 79 (38%) had stage I disease, 41 (20%) stage II, and 87 (42%) stage III disease.

FOLLOW UP

Patients were reviewed every three months for the first year and every six months thereafter at a special gastric follow up clinic run by a physician (ATRA) and a surgeon (DJ). Only one of the 207 patients was lost to follow up and 152 patients were followed up for a minimum of five years or until death. If recurrence was suspected ultrasonography or computed tomography and an endoscopic examination were arranged. If the patient died the cause was sought from our own and general practitioners' records and from the Yorkshire regional cancer registry.

TABLE I—*1987 Unified International tumour, node, metastases (TNM) staging of gastric cancer[13] as used in current study*

Stage of disease	TNM		
I	T1N0M0	T1N1M0	T2N0M0
II	T1N2M0	T2N1M0	T3N0M0
IIIa	T2N2M0	T3N1M0	T4N0M0
IIIb	T3N2M0	T4N1M0	

T1 = confined to mucosa/submucosa.
T2 = invading muscularis propria to subserosa.
T3 = through serosa.
T4 = through serosa with involvement of contiguous structures.
N0 = no nodal involvement.
N1 = affected nodes < 3 cm from tumour.
N2 = affected nodes > 3 cm from tumour.
M0 = no distant metastases.

TABLE II—*Numbers of patients diagnosed as having gastric cancer who underwent potentially curative resection or who had incurable disease during four five year periods from 1970 to 1989*

	1970-4	1975-9	1980-4	1985-9
Potentially curative resection	31	34	56	86*
incurable disease	66	76	70	74
	97	110	126	160

*$p < 0.01$ for comparisons between 1985-9 and 1970-4.

TABLE III—*Treatment of 493 patients with gastric cancer during four five year periods from 1970 to 1989. Values are numbers (percentages) of patients*

Procedure	1970-4 (n = 97)	1975-9 (n = 110)	1980-4 (n = 126)	1985-9 (n = 160)
Resection:				
"Curative"	31 (31)	34 (30)	56 (44)	86 (53)
Palliative	25 (26)	28 (26)	39 (31)	49 (31)
Palliative bypass	9 (9)	11 (10)	13 (10)	5 (3)
Laparotomy only	25 (26)	23 (21)	11 (9)	7 (5)
No operation	7 (8)	14 (13)	7 (6)	13 (8)

STATISTICAL ANALYSIS

Cumulative survival was calculated by the life table method of Kaplan and Meier.[16] Differences in survival times between groups of patients were analysed by the log rank method.[17] Cox's proportional hazards model[18] was used to assess the prognostic value of individual variables. The χ^2 test was used to compare the proportions of patients in whom curative resection was possible for each five year and 10 year period.

Results

INCREASE IN INCIDENCE OF "CURABLE" CASES

Over the 20 year period the proportion of patients in whom potentially curative resection was possible increased significantly ($p < 0.01$) from 31% of all patients with gastric cancer in 1970-4 to 53% in 1985-9 (table II). The proportion of patients who underwent resection either for "cure" or for palliation increased from 56% of all patients in the early 1970s to 84% of all cases by the late 1980s (table III). Similar favourable changes were seen in the proportions of patients who had early gastric cancer from 1% of all cases of gastric cancer in the first five year period to 15% of all cases in the last five year period ($p < 0.01$) and of patients with stage I disease (from 4% to 26% of all cases; $p < 0.001$; table IV). This trend towards earlier diagnosis of gastric cancer coincided with a fourfold increase in the number of upper gastrointestinal endoscopies performed between 1976 and 1990 (table V).

OPERATIVE MORTALITY AND MORBIDITY

Operative mortality one month after operation was 6%. Operative mortality was considerably lower in the second decade (5%) than in the first decade (9%), but the decrease was not significant. A further 46 patients (22%) sustained serious postoperative complications such as chest infection (16 cases), wound infection (seven cases), anastomotic leakage (10 cases), deep venous thrombosis (three cases), and various other complications (10 cases). Postoperative complications were significantly less common ($p < 0.01$) in the second decade (affecting 24 of 141 patients (17%)) than in the

TABLE IV—*Numbers (percentages) of patients with stage I disease during four five year periods from 1970 to 1989*

	1970-4 (n = 97)	1975-9 (n = 110)	1980-4 (n = 126)	1985-9 (n = 160)
Stage I disease	4 (4)	14 (13)	19 (15)	42 (26)*

*$p < 0.01$ for comparisons between 1985-9 and 1970-4.

TABLE V—*Numbers of upper gastrointestinal endoscopies performed each year from 1976 to 1990*

Year	No of gastroscopies
1976	1025
1977	1508
1978	1804
1979	2046
1980	2183
1981	2315
1982	2422
1983	2865
1984	2711
1985	2714
1986	2625
1987*	3540
1988	3819
1989	4100
1990	4200

*Open access endoscopy introduced.

first decade (affecting 22 of 66 patients (33%)). Thus operative mortality and postoperative morbidity diminished despite the use of more radical (R2) methods of resection in the second decade than in the first decade.

SURVIVAL

Cumulative survival (95% confidence interval) calculated by life table analysis for the 207 patients who underwent potentially curative resection was 60% (52% to 68%) at five years and 55% (46% to 64%) 10 years after operation. None of the patients in whom potentially curative resection was not possible survived for five years. Five year survival was 98% (92% to 100%) in the 43 patients with early gastric cancer, 93% (87% to 100%) in patients with stage I disease, 69% (50% to 87%) in those with stage II disease, and 28% (17% to 39%) in those with stage III disease (figure). If operative mortality was included five year survival was 54% (46% to 63%) for the 207 patients who underwent potentially curative resection, 91% (82% to 99%) for patients with early gastric cancer, 87% (79% to 95%) for patients with stage I disease, 65% (47% to 83%) for those with stage II disease, and 24% (14% to 34%) for those with stage III disease. Among the 152 patients who were followed up for a (potential) minimum period of five years the absolute, crude five year survival (including all deaths after operation and on subsequent follow up) was 45% (68 out of 152 patients). Metastasis to lymph nodes (N) (risk ratio 6·5; $p < 0.00001$) and depth of tumour penetration (T) (risk ratio 3·3; $p < 0.0001$) were found to be the most important predictors of outcome as determined by Cox's proportional hazards model. The corrected five year survival of patients without lymph node metastases was 88% and with lymph node metastases only 35% ($p < 0.001$).

Discussion

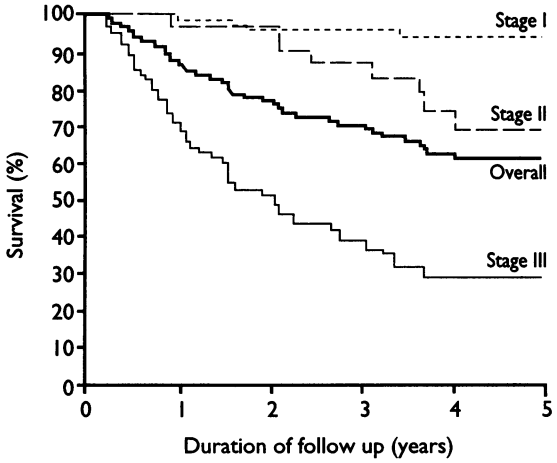
As far as we are aware, these results are the best that have been reported in the surgical treatment of gastric carcinoma in Britain. The principal findings were that between 1970 and 1989 the absolute numbers of patients referred for surgical treatment of gastric cancer increased by 50% while the proportion of all patients referred in whom potentially curative resection was possible increased from 30% in 1970 to 55% in 1989. Hence, twice as many patients underwent potentially curative resection in the late 1980s as in the early 1970s. At the same time a favourable and significant "shift to the left" in pathological TNM stage took place, whereby patients with early gastric cancer increased from 1% of all cases referred in 1970 to 15% in 1989; patients with stage I disease increased from 4% to 26% of all cases; and the proportion of all patients with gastric cancer who had stage I and II disease increased significantly from 14% in 1970 to 31% in 1989. It was thus inevitable that the results of surgery should improve; indeed overall five year survival for all patients referred more than doubled from 15% of all cases in 1970 (51% after potentially curative resection) to 37% of all cases in 1989 (71% after potentially curative resection).

We do not think that the increase in the number of patients with gastric cancer referred to this unit was because of an increase in the incidence of gastric cancer in Leeds. The increase in the number of patients referred probably reflects better diagnosis because of open access endoscopy and hence the possibility of surgical resection rather than any true increase in the incidence of gastric cancer in Leeds.

INTERNATIONAL COMPARISONS

The corrected five year survival of 60% among the 207 patients who underwent potentially curative resection in this series is two to three times the average five year survival reported from several major British centres in the past 20 years[2-7 33 34] and twice the average five year survival after potentially curative resection reported from Europe, Scandinavia, and the United States in the 1970s and '80s.[19 20 35-45] Although such comparisons are of limited value because of the existence of unknown and uncontrolled variables such as methods of case selection, patients' characteristics, and the surgical methods used, it is at least encouraging that in our own centre more than half the patients referred can now undergo potentially curative resection. By the late 1980s the corrected five year survival after potentially curative resection had reached 71%, a figure that is rare outside of Japan. Msika *et al* recently reported 44% survival at five years after potentially curative resection in France,[19] and Shiu *et al* 47% survival at five years after the same operation in the United States,[20] results which are not greatly dissimilar to our own. These corrected figures for five year survival exclude patients who died because of the operation (6% in this series) and also patients who died during follow up of causes unrelated to gastric cancer (12% of all potentially curative resections). Hence, the corrected figures quoted here and in most other publications for five year survival tend to put the results in a somewhat flattering light, whereas the figures for absolute survival after five years of follow up look less impressive, as we make clear in the results section.

This paper provides the first clear evidence that survival after surgical treatment of stages I and II gastric cancer in Britain (93% and 69% five year survival, respectively, in this series) can be as good in Britain as in Japan.[8] Among patients with stage III disease, however, we achieved only 28% survival at five years, whereas the best Japanese centres report about 40% in such patients.[8 9] The reason for the disparity between their results and ours in stage III disease is a matter for speculation. Japanese stage III disease might be biologically less aggressive, but that seems implausible. Japanese surgeons may have performed more radical resections, especially with regard to lymph node clearance, than we were able to achieve. In



Corrected five year survival curves in relation to stage of disease. Operative deaths were excluded

the 1980s, however, we performed standard R2 resections in most cases, just as the Japanese do, and the Japanese themselves have shown that even more radical lymphadenectomies (R3) do not yield better results than R2 resections do.[21] Thus, the explanation that we find most persuasive is that whereas we used radical surgical resection alone without any form of adjuvant therapy the Japanese have usually used chemotherapy in addition to radical resection in patients with stage III disease. They have reported that surgery plus chemotherapy yields considerably better results than surgery alone.[22-24] The study by Estape *et al* lends further strong support to the idea that adjuvant chemotherapy confers considerable survival advantage on patients with stage III disease.[25] Just as adjuvant chemotherapy with immunomodulation is advocated today for patients with Dukes' C colon cancer,[26] in the treatment of patients with gastric cancer patients with stage III disease should probably receive similar adjuvant therapy.[23]

EARLIER DIAGNOSIS

Admittedly, the 207 patients who underwent potentially curative resection represent a very selected population. The tragedy of the 286 remaining patients referred in whom potentially curative resection was impossible is that their disease was too advanced at the time of diagnosis. The crucial factor then is earlier diagnosis if the results of treatment of gastric cancer in Britain and the rest of the West are to improve. In Japan mass screening has proved to be very effective in the diagnosis of gastric cancer at an early stage.[27] The lower incidence of gastric cancer in Britain and the West, however, would make such a screening programme of asymptomatic patients impractical. One possible alternative that has been suggested is the early investigation of patients with dyspepsia by means of open access endoscopy. As the peak incidence of gastric cancer occurs in the 6th and 7th decades and since gastric cancer is very uncommon in people under 40 years of age the investigation of patients over 40 years with dyspepsia is one practical way of diagnosing gastric cancer at an early stage.

We found that over the 20 year period of study and especially since the introduction of open access endoscopy the proportion of patients with early gastric cancer rose from 1% to 15% and of patients with stage I disease from 4% to 26%. Studies of open access endoscopy from other centres in Britain[10-12] have also shown that such a vigorous approach to diagnosis yielded worthwhile returns and resulted not only in earlier diagnosis of gastric cancer but also in the diagnosis of the disease at an earlier pathological stage, when cure by means of radical surgery was more likely. While end results of such surgery have not yet been reported from these centres results such as we report will probably be produced from many centres with a special interest in gastric cancer during the next decade.

BIAS

In an observational study such as this there are two potential sources of bias which, if present, could alter the interpretation of our results. The first is known as lead time bias, in which the starting date of the patient with cancer is brought forward if the cancer is detected sooner. The apparent survival time when measured from the date of diagnosis would therefore be longer.[46] A second source of bias is length bias, in which some of the cancers detected at an early stage may be less aggressive than those detected at a later stage, such that conceivably they might have regressed or failed to progress to overt, invasive cancer.[47] Lead time bias and length bias traditionally apply to studies of cancer screening, which is defined as the detection of disease at such an early stage that symptoms or signs are absent or at least have not led the patient to seek medical attention. All the patients in this study, however, had symptoms and had sought medical attention through their general practitioners before being referred to us for investigation. Nevertheless, the patients in this study were probably investigated at an earlier stage in their clinical presentation than is possible in most centres, and similar criticisms may therefore be applied to this study.

Ultimately, the only way in which this can be proved not to be the case would be to show that mortality from gastric cancer is reduced in the community, but such a study would be difficult to set up in Britain. In Japan, where screening for gastric cancer has been used, studies have shown that mortality from gastric cancer within the community can be reduced by early diagnosis.[48]

Even if the starting date of our patients had been brought forward through prompt investigation by open access endoscopy service, survival would have been merely prolonged. The fact that survival among the 207 patients who underwent potentially curative resection was 60% at five years and only slightly less (55%) at 10 years suggests that patients were not merely living a few months longer but were in fact "cured" of their disease. These findings are supported by data from larger Japanese studies,[9 28] which have reported only 3% to 8% of deaths from recurrent cancer between five and 10 years of follow up. Most patients who die of recurrent cancer after potentially curative resection for gastric cancer die within three or four years of operation. Furthermore, all the cancers detected in this study were shown to be invasive adenocarcinomas, 52% of which were shown on histological grading to be poorly differentiated or anaplastic, a finding similar to that reported in another study from Glasgow of 128 patients who underwent curative resection and in whom there was no cancer screening or any attempt at early diagnosis by means of open access endoscopy.[6] Thus, we feel that the gastric cancers detected and treated in our study were likely to have been, as far as can be judged, as aggressive as tumours detected at a later stage in other British studies, though it is impossible to state categorically that this is the case.

EFFECT OF SURGERY

The large decrease in operative mortality (9% to 5%) and the significant decrease in postoperative complications from 33% to 17% were gratifying and were attributable not only to improved surgical techniques but also to improvements in anaesthesia, metabolic care, and intravenous nutrition. It is doubtful whether we will ever match the operative mortality of 1-3% reported by Japanese surgeons in such cases because our patients are 11 years older on average than their Japanese counterparts (68 *v* 57 years),[28] are more obese, and have more atheroma, diabetes, and ischaemic heart disease.[8] Nevertheless, an operative mortality of 5% at one month is still too high and could perhaps be halved by the end of the century by standardisation of operative techniques, obtaining better access to the oesophagus, and improvement in perioperative nutritional support and general care. It will also require greater concentration of cases and specialisation than is currently provided in this country, but that is the trend in all aspects of surgery, and surgery for gastric cancer should be no exception.

The influence of radical surgical resection and extensive lymphadenectomy on the survival of patients with gastric cancer remains controversial. Metastasis to lymph nodes is certainly an important determinant of outcome,[29 30] as our results clearly show. The standard operative procedure in Japan is an R2

resection, in which an extra "tier" of lymph nodes (N2) is removed in addition to the nodes situated close to the stomach (N1 nodes), which are normally removed as part of a wide gastric resection (known as R1 resection). Data from Japan[8 9 30] have consistently supported the view that the R number of resection should exceed the N number if recurrence is to be minimised and an "absolute" curative resection achieved. For example, Nakajima and Nishi reported that in patients with N1 nodal metastases, five year survival was 4% after R0 resection (incomplete dissection of N1 nodes), 46% after R1 resection, and 56% after R2 resection.[9] Kodama and colleagues also found that in patients with nodal metastases who underwent potentially curative resection, five year survival was 18% after simple gastric resection only but 39% after gastric resection combined with extensive lymphadenectomy.[30] Unfortunately, these studies were all retrospective, were conducted over widely differing periods of time, and are further weakened by the use of adjuvant chemotherapy in some, but not all, patients, making it difficult to deduce what differences in survival were due to differences in operative technique.[30] A recent prospective multicentre study in Germany of 2394 patients, however, has clearly shown a significant survival advantage of radical (R2) lymphadenectomy over the less radical (R1) resection in patients with stage II (55% *v* 27%; $p < 0.001$) and stage IIIA disease (38% *v* 25%; $p < 0.05$).[31] Furthermore, operative mortality (5%) and morbidity (30%) among patients who underwent R2 resection was no greater than in patients who underwent R1 resection (5% and 29%, respectively). A similar Medical Research Council study of R1 *v* R2 resection is currently in progress in Britain,[32] and the results are eagerly awaited.

Since the late 1970s it has been our practice to perform radical (R2) resection unless for reasons of a patient's advanced age or the presence of serious associated disease such an approach seemed too dangerous. Operative mortality and morbidity in this series were found to have decreased greatly in the 1980s compared with the 1970s, despite the fact that surgical resections were more radical (R2) in the 1980s than in the 1970s. Thus, we have at least shown that such radical (R2) resections are safe, as Japanese and German surgeons have reported. Over the 20 year period of this study, five year survival increased from 51% in the early 1970s, when R1 resections were commonly performed, to 71% in the late 1980s, when R2 resections were the rule. This improvement in outcome, however, cannot be ascribed solely to the use of more radical types of gastric resection because during this period large increases took place in the proportions of patients with early gastric cancer (1% to 15%) and stage I disease (4% to 26%). We were unable to compare the results of R1 and R2 resection, stage for pathological stage, because of the relatively small numbers of patients in each pathological subgroup. Despite the aggressive surgical approach to gastric cancer the quality of life of patients after radical (R2) resection is usually remarkably good as we have previously reported.[49 50]

Clinical implications

- 10 000 people die each year from gastric cancer in Britain
- Gastric cancer is regarded as almost incurable, five year survival being 5%
- This study shows that gastric cancer can be diagnosed at an earlier stage through more widespread use of endoscopy
- The outlook for patients with stages I and II disease in Britain is as good as that in Japan
- Further improvements in outcome will follow from greater efforts towards earlier diagnosis of gastric cancer

CONCLUSIONS

In conclusion, the traditional British or Western view of gastric cancer—that it is usually a fatal disease—is out of date. Over a 20 year period from 1970 to 1989 we found that, thanks mainly to a fourfold increase in the use of endoscopy, a significantly greater proportion of patients was diagnosed at a relatively early and curable stage. The outcome of surgical resections improved greatly; operative mortality and morbidity about halved and five year survival after potentially curative resection increased from 51% to 71%, while overall five year survival increased from 15% to 37% of all cases referred. Stage for pathological stage the results of surgery were found to approach those reported from Japan. Further improvements in outcome will follow greater efforts at educating doctors and the public that the onset of pain, dyspepsia, heartburn, or anaemia in patients over 40 years of age should be investigated by means of endoscopy and biopsy; by the concentration of cases in specialised centres that treat large numbers of cases; and, probably, by the use of adjuvant therapy in patients with more advanced, stage III disease.

1 Office of Population Censuses and Surveys. *Mortality statistics by cause.* London: HMSO, 1989.
2 Hawley PR, Westerholm P, Morson BC. Pathology and prognosis of carcinoma of the stomach. *Br J Surg* 1970;57:877-83.
3 Cassell P, Robinson JO. Cancer of the stomach: a review of 854 patients. *Br J Surg* 1976;63:603-7.
4 Desmond AM. Radical surgery in treatment of carcinoma of stomach. *Proceedings of Royal Society of Medicine* 1976;69:867-9.
5 Costello CB, Taylor TV, Torrance B. Personal experience in the surgical management of carcinoma of the stomach. *Br J Surg* 1977;64:47-51.
6 Cunningham D, Hole D, Taggart DJ, Soukop M, Carter DC, McArdle CS. Evaluation of the prognostic factors in gastric cancer: the effect of chemotherapy on survival. *Br J Surg* 1987;74:715-20.
7 Allum WH, Powell DJ, McConkey CC, Fielding JWL. Gastric cancer: a 25 year review. *Br J Surg* 1989;76:535-40.
8 Maruyama K, Okabayashi K, Kinoshita T. Progress in gastric cancer surgery in Japan and its limits of radicality. *World J Surg* 1987;11:418-25.
9 Nakajima T, Nishi M. Surgery and adjuvant chemotherapy for gastric cancer. *Hepatogastroenterology* 1989;36:79-85.
10 Gear MWL, Ormiston MC, Barnes RJ, Rocyn-Jones J, Voss GC. Endoscopic studies of dyspepsia in the community: an "open-access" service. *BMJ* 1980;280:1135.
11 Hallissey MT, Allum WH, Jewkes AJ, Ellis DJ, Fielding JWL. Early detection of gastric cancer. *BMJ* 1990;301:513-5.
12 Kerrigan DD, Brown SR, Hutchinson GH. Open-access gastroscopy: Too much to swallow? *BMJ* 1990;300:374-6.
13 Japanese Research Society for Gastric Cancer. The general rules for the gastric cancer study in surgery and pathology. *Jpn J Surg* 1981;11:127-45.
14 Kennedy BJ. The unified international gastric cancer staging classification. *Scand J Gastroenterol* 1987;22(suppl 133):11-3.
15 Murakami T. Early cancer of the stomach. *World J Surg* 1979;3:685-92.
16 Kaplan EL, Meier P. Non-parametric estimation from incomplete observations. *Journal of American Statistics Association* 1958;53:457-81.
17 Peto R, Pike MC, Armitage P, Breslow NE, Cox DR, Howard SV, *et al.* Design and analysis of randomised clinical trials requiring prolonged observation of each patient. Analysis and examples. *Br J Cancer* 1977;35:1-39.
18 Cox DR. Regression models and life tables. *Journal of Royal Statistics Society B* 1972;34:187-202.
19 Msika S, Chastang C, Houry S, Lacaine F, Huguier M. Lymph node involvement as the only prognostic factor in curative resected gastric carcinoma; a multivariate analysis. *World J Surg* 1989;13:118-23.
20 Shiu MF, Penrotti M, Brennan MF. Adenocarcinoma of the stomach: a multivariate analysis of the clinical, pathologic and treatment factors. *Hepatogastroenterology* 1989;36:7-12.
21 Kaibara N, Sumi K, Yonekawa M, Ohta M, Makino M, Kimura O, *et al.* Does extensive dissection of lymph nodes improve the results of surgical treatment of gastric cancer. *Am J Surg* 1990;159:218-21.
22 Nakajima T, Fukami I, Ohashi T, Kajitani T. Long-term follow-up study of gastric cancer patients treated with surgery and adjuvant chemotherapy with mitomycin C. *International Journal of Clinical Pharmacology* 1978;16:209-16.
23 Kim JP. The concept of immunochemosurgery in gastric cancer. *World J Surg* 1987;11:465-72.
24 Inokuchi K. Prolonged survival of gastric cancer patients on a specific adjuvant chemotherapy. *Jpn J Surg* 1984;14:351-9.
25 Estape J, Grau JJ, Lcobendas F, Curto J, Daniels M, Vinolas N, *et al.* Mitomycin C as an adjuvant treatment to resected gastric cancer. *Ann Surg* 1991;213:219-21.
26 Moertel CG, Fleming TR, Macdonald JS, Haller DG, Laurie JA, Goodman PJ, *et al.* Levamisole and fluorouracil for adjuvant therapy of resected colon carcinoma. *N Engl J Med* 1990;322:352-8.

27 Hisamichi S, Sugawara N. Mass screening for gastric cancer by x-ray examination. *Jpn J Clin Oncol* 1984;14:211-23.
28 Itoh H, Oohata Y, Nakamura K, Nagata T, Mibu R, Nakayama F. Complete ten-year postgastrectomy follow-up of early gastric cancer. *Am J Surg* 1989;158:14-6.
29 Maruyama K. The most important prognostic factors for gastric cancer patients. A study using univariate and multivariate analyses. *Scand J Gastroenterol* 1987;22(suppl 133):63-8.
30 Kodama Y, Sugimachi K, Soejima K, Matsusaka T, Inokuchi K. Evaluation of extensive lymph node dissection for carcinoma of the stomach. *World J Surg* 1981;5:241-8.
31 Siewert JR, Bottcher K, Roder JD, Busch R, Hermanek P, Meyer HJ, and the German Gastric Carcinoma Study Group. Prognostic relevance of systematic lymph node dissection in gastric carcinoma. *Br J Surg* 1993;80:1015-8.
32 Cuschieri A. Gastrectomy for gastric cancer: definitions and objectives. *Br J Surg* 1986;73:513-4.
33 Akoh JA, Sedgwick DM, Macintyre IMC. Improving results in the treatment of gastric cancer: an 11-year audit. *Br J Surg* 1991;78:349-51.
34 Irving TT, Bridger JE. Gastric cancer. An audit of 122 consecutive cases and the results of R1 gastrectomy. *Br J Surg* 1988;75:106-9.
35 Inberg MV, Vuori J, Viikari SJ. Carcinoma of the stomach. A follow up study of 1963 patients. *Acta Chir Scand* 1972;138:195-201.
36 Nielsen SA, Amdrup E, Christiansen P, Fenger C, Jensen HE, Lindskov J, *et al.* Carcinoma of the stomach. An analysis of 385 cases treated 1955-1964. *Acta Chir Scand* 1974;140:313-20.
37 Svennevig JL, Nysted A. Carcinoma of the stomach. A ten year material. *Acta Chir Scand* 1976;142:78-86.
38 Buchhloltz TW, Welch CE, Malt RA. Clinical correlates of resectability and survival in gastric carcinoma. *Ann Surg* 1978;188:711-5.
39 Adashek K, Sanger J, Longmire WP Jr. Cancer of the stomach. Review of consecutive 10 year intervals. *Ann Surg* 1979;189:6-10.
40 Shiu MH, Papacristou DN, Kosloff C, Eliopoulos G. Selection of operative procedure for carcinoma of mid stomach. *Ann Surg* 1980;192:730-7.
41 Yan C, Brooks JR. Surgical management of gastric adenocarcinoma. *Am J Surg* 1985;149:771-4.
42 Sjostedt S, Pieper R. Gastric cancer. Factors influencing long term survival and post-operative mortality. *Acta Chir Scand Suppl* 1986;530:25-9.
43 Hartley LC, Evans E, Windsor CJ. Factors influencing prognosis in gastric cancer. *Aust N Z J Surg* 1987;57:5-9.
44 Meyers WC, Damiano RJ, Postlethwait RW, Rotolo FS. Adenocarcinoma of the stomach: changing patterns over the last 4 decades. *Ann Surg* 1987;205:1-8.
45 Lindahl AK, Harbitz TB, Liavag I. The surgical treatment of gastric cancer: a retrospective study with special reference to total gastrectomy. *Eur J Surg Oncol* 1988;14:55-62.
46 Day NE. Quantitative approaches to the evaluation of screening programs. *World J Surg* 1989;13:3-8.
47 Neugut AI, Pita S. Role of sigmoidoscopy in screening for colorectal cancer: a critical review. *Gastroenterology* 1988;95:492-9.
48 Hisamichi S. Screening for gastric cancer. *World J Surg* 1989;13:31-7.
49 Sue-Ling HM, Martin I, Griffith J, Ward DC, Quirke P, Johnston D, *et al.* Early gastric cancer: 46 patients treated in one surgical department. *Gut* 1992;33:1318-22.
50 Sue-Ling HM, Young S, Griffith J, Selby P, Johnston D. Quality of life after radical (R2) gastrectomy for gastric cancer. *Gut* 1993;34(suppl 1):S15.

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Road traffic and adverse effects on respiratory health in children

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Abstract

***Objectives*—To examine whether road traffic in a big city has a direct effect on pulmonary function and respiratory symptoms in children.**

***Design*—Cross sectional study.**

***Setting*—Of all 7445 fourth grade children (aged 9-11 years) in Munich, 6537 were examined. Of the children with German nationality and the same residence during the past five years and known exposure data, 4678 questionnaires and 4320 pulmonary function tests could be analysed.**

***Main outcome measures*—Variables of pulmonary function by forced expiration and respiratory symptoms reported in a questionnaire; census data on car traffic collected in the school district.**

***Results*—Density of car traffic ranged from 7000 to 125 000 cars per 24 hours. Multiple regression analysis of peak expiratory flow showed a significant decrease of 0·71% (95% confidence interval 1·08% to 0·33%) per increase of 25 000 cars daily passing through the school district on the main road. Maximum expiratory flow when 25% vital capacity had been expired was decreased by 0·68% (1·11% to 0·25%). In contrast, response to cold air challenge was not increased. The adjusted odds ratio for the cumulative prevalence of recurrent wheezing with the same exposure was 1·08 (1·01 to 1·16). Cumulative prevalence of recurrent dyspnoea was increased, with an odds ratio of 1·10 (1·00 to 1·20). Lifetime prevalence of asthma (odds ratio 1·04; 0·89 to 1·21) and recurrent bronchitis (1·05; 0·98 to 1·12) were not significantly increased.**

***Conclusions*—High rates of road traffic diminish forced expiratory flow and increase respiratory symptoms in children.**

Introduction

The effects of both indoor and outdoor pollutants on health are of great public interest. Several studies have confirmed an association between both outdoor air pollutants[1-5] and indoor pollutants[6-9] and respiratory health. With increasing motorisation throughout the world the emission of potentially hazardous substances is increasing. One main source of outdoor air pollution is road traffic, which produces a mixture of volatile hydrocarbons, airborne particles, nitrogen oxides, and carbon monoxide.[10,11] As there are only a few reports of the effects on respiratory health of car exhaust fumes we examined census data on cars in relation to respiratory symptoms and pulmonary function in children. In Munich air pollution is caused primarily by car exhaust fumes and only to a small degree by industry.

Subjects and methods

STUDY SITE

Munich is 530 metres above sea level in the south of Germany and is the capital of Bavaria. It has a population of 1·27 million (July 1990) in an area of 3 104 400 m^2.[12] In 1990 there were 649 000 cars registered in Munich. Movements of traffic in the inner city increased by about 40% between 1970 and 1990 with traffic at the city limits going up by more than 125%. Nearly a million cars pass the city border every day.[13]

Permanent multicomponent air monitoring stations have been installed at a height of 3 metres in the city. During the study the average mean values at the Karlsplatz-Stachus site, where 70 000 cars pass by every 24 hours, were 0·148 mg/m^3 for nitrogen monoxides, 0·076 mg/m^3 for nitrogen dioxides, 4·609 mg/m^3 for carbon monoxide, and 0·016 mg/m^3 for sulphur dioxide. These figures did not exceed standards for air quality.[14] To validate further the assessment of exposure, data from more than 250 measurements of nitrogen dioxide distributed over the city measured in 1984-7[15] and of benzene, toluene, hydrocarbons, and ozone measured in 1988[16] were correlated to rates of car traffic. If there was more than one measurement in a single school district the arithmetic mean was taken.

STUDY DESIGN

This report shows the results of a cross sectional study carried out from 1989 to 1990 on all children in the fourth grade at school (age 9-11 years) in the city of Munich. The main objective of the Munich asthma and