Predicted Survival in Peptic Ulcer Patients Based on Computer Analysis of Preoperative Variables

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A prospective study designed to emphasize and quantitate the operative risk of patients preparing to undergo surgery for the treatment of complicated peptic ulcer disease is presented. Data were gathered from 347 consecutive patients operated on with benign gastric and/or duodenal ulcers in a Veterans Hospital over an 8-year period. Resident surgeons performed all operations and for the most part decided on the operative procedure used, with advice from attending faculty. Preoperative factors influencing the operative mortality in 34 patients were compared with those in surviving patients and subjected to a multivariant discriminant function analysis by computer. Ten variables were identified as being significantly different ($P < 0.05 - P < 0.01$) between the survivor and non-survivor groups. Using the discriminant weights of these variables, a computer program was written to calculate the 30-day operative mortality of any preoperative patient based on this past experience. The accuracy of the program is excellent in good risk patients; i.e., a predicted greater than 90% chance of survival was correct 98.9% of the time with 3 deaths in 279 patients. Patients at the low end of the scale (less than 10%) were predicted with 85% accuracy. In the last 8 months, 29 patients have undergone surgery after prospective computer assessment of their operative risk. All have survived with a predicted chance of greater than 50%. Four patients died with survival chances predicted at 4, 2, 1, and 1%. The computer may be used as an educational vehicle for sharpening our preoperative assessment of a patient with ulcer disease, particularly regarding operative risk.

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THE PURPOSE of this study is to emphasize with the aid of computer analysis, the important factors influencing operative risk in patients with complicated peptic ulcer disease. The paper is divided into two parts: 1) a retrospective study of 347 consecutive patients operated on for this disease in the Miami Veterans Administration Hospital from January 1967 through December 1974; and 2) the application of multivariant discriminant function analysis of this retrospective data to a prospective group of similar patients for preoperative asssessment of their operative risks.

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Retrospective Material

There are 264 patients with duodenal and 83 patients with gastric ulcers in the series. The type ulcer alone did not significantly influence operative mortality rates within 30 days of surgery in that there were 23 non-survivors with duodenal ulcer disease and 11 with gastric ulcers. Patients with cancer, gastritis or multiple stress ulcers were not included. The mean age was 54 years and 63% of this patient population was over 50 years of age when they received their surgical procedure. The age distribution is shown in Table 1. The 30-day operative mortality of 10% was related to age as shown in Table 2 with a 90% mortality occurring in the 10 patients 80 years of age or over.

The indications for surgery in this series of patients showed that hemorrhage and perforation contributed prominently in the non-survivor group as shown in Table 3. Several patients had more than one indication.

Mortality was also definitely related to operative urgency in that of the 126 patients undergoing emergency surgery, the operative mortality was 25%. There were 221 patients done electively with only two deaths resulting in an operative mortality of 1% which compares favorably with other recently reported series.[1–5] The 168 surgical cases with benign duodenal ulcers done electively all survived, and of the 53 gastric ulcers done electively, there were two operative deaths. On the other hand, if these cases were done under emergency

TABLE 1. *Age Distribution*

Age	Number	Per Cent
20–29	10	2.9
30–39	31	8.9
40–49	87	25.1
50–59	115	33.1
60–69	71	20.5
70–79	23	6.6
80 and over	10	2.9
Totals	347	100.0

conditions the operative mortality was 24 and 30% respectively. The surgical procedure employed did not influence the operative risk factor; of the 126 patients undergoing an elective vagotomy and drainage procedure, there were no operative deaths; and there were only 2 deaths in 89 patients who underwent elective resections. Similarly, in those patients in which these two types of procedures were done under emergency conditions, the operative mortality was much higher but not significantly different at 30% and 24% respectively for vagotomy and drainage versus gastric resection. Forty patients underwent an emergency operation in which a simple closure of a perforated ulcer was performed and this resulted in 8 deaths or an operative mortality of 20%.

There were four major preoperative complications that statistically influenced the outcome in these surgically treated peptic ulcer patients. Pulmonary problems were most frequent with 24 patients having this complication listed as a serious factor. Cardiovascular, renal, and liver diseases were also factors as shown in Table 4. In the 252 patients who had no serious preoperative complications, there was only one postoperative death (Table 5). On the other hand, of the 62 patients with one serious preoperative complication, 24% did not survive, and as the number of complications increased, so did the operative mortality. Moreover, operative urgency was also related to preoperative complications. Of the 252 patients with no complications only 26% were done as emergencies, while 56% of patients with one serious preoperative complication, and 76% having two or more complications were done as emergencies presumedly from a reluctance to subject seriously ill patients to surgery for peptic ulcer disease except under dire circumstances. Postoperative complications, such as sepsis, peritonitis, fistula, recurrent hemorrhage, wound dehiscence, local infection, delayed emptying, blood reaction and recurrence were listed as contributing factors but in no instance was mortality related to one of these complications alone.

TABLE 2. *Age Related Mortality*

Age	Patients	Deaths	Per Cent
20–39	41	0	0
40–49	87	4	5
50–59	115	8	7
60–69	71	7	10
70–79	23	6	26
80 and over	10	9	90
Totals	347	34	10

TABLE 3. *Surgical Indications*

Indication	Total	Survivors	Non-survivors
Hemorrhage	157	135	22 (14%)
Perforation	77	64	13 (17%)
Obstruction	57	56	1 (2%)
Intractability	95	95	0 (0%)

With the use of the Univac 1109 computer, a multivariant discriminant function analysis was performed on the data from this retrospective series of patients and the significance of each variable in predicting survival was calculated. Table 6 shows the rank of each contributing variable. Renal disease was weighted highest in that only 3% of the 313 survivors but 41% of the 34 non-survivors had this pre-existing complication. Although hemorrhage was the most frequent indication for surgery, it made the least contribution to the predicted outcome in as much as it was present in 43% of those patients surviving. However, all 10 of the variables listed in Table 6 were statistically significant ($P < 0.01$–$P < 0.05$) between the surviving and non-surviving groups. With the data analyzed in this fashion, a program was written for a prospective analysis.

This program is available on many computer terminals but its data base is drawn from the patient population in a particular hospital over the past 8 years. It can be updated at anytime as information on more patients becomes available. By means of a typewriter terminal the computer asks the surgeon several questions concerning the preoperative workup, such as, the patients age; diagnosis; whether the procedure is being done as an emergency or on an elective basis; what the indication for surgery is: obstruction, perforation, hemorrhage, or intractability; and whether any one of four serious preoperative complications are present, including pulmonary, cardiovascular, liver or renal disease. All of these questions can be answered by a number or a simple letter for yes-no on the keyboard. The computer then

TABLE 4. *Mortality Related to Only One Preoperative Complication*

	Total	Survivors	Non-survivors
Pulmonary	24	18	6 (25%)
Cardiovascular	18	15	3 (17%)
Renal	13	9	4 (31%)
Liver	7	5	2 (29%)
Total	62	47	15 (24%)

TABLE 5. *Mortality Related to Preoperative Complications*

Complications	Total	Survivors	Non-survivors
0	252	251	1 (0%)
1	62	47	15 (24%)
2	23	12	11 (48%)
3	9	3	6 (67%)
4	1	0	1 (100%)
Total	347	313	34 (10%)

TABLE 7. *Prospective Series*

Preop Predicted Survival	Number Patients	Actual Survival
99–82%	22	22
75–46%	3	3
4%	1	0
2%	1	0
1%	2	0

mathematically predicts the probability of the patient surviving 30 days following surgery based on the 347 previous cases. As an example, one can choose a 75-year-old man with duodenal ulcer undergoing elective surgery for hemorrhage and intractability. One serious preoperative complication is listed in his case as pulmonary disease. Once these data are entered, the computer prediction is printed as an 81% probability of surviving 30 days following operation. As another example, let us assume the same patient presents himself under different circumstances and is operated on with a severe hemorrhage as an emergency. His chances of survival would be predicted by the computer to drop to 35%. To emphasize further the effect of pre-existing diseases, a 65-year-old man with a duodenal ulcer was operated on as an emergency for hemorrhage. With no serious preoperative complications, his predicted survival would be 96%. However, if he also has severe liver disease, the predicted survival would be 88%; cardiovascular, 84%; pulmonary, 45%, and severe renal disease would give him a predicted survival of 2%. To illustrate the influence of two preoperative complications, the same patient with liver and cardiovascular complications preoperatively would be predicted to have a 55% chance of surviving his operation. Pulmonary and liver complications together increase the risk of surgery, and survival would be predicted at 12%. Pulmonary and cardiovascular complications would drive survival to 8% and renal disease along with any other serious complication would be predicted at only 1%.

The accuracy of this program was tested on all of the retrospective patients and was found to be very precise in its prediction of good risk patients. If a patient's operative survival was predicted at greater than 90%, the prediction was correct 98.9% of the time with only three deaths occurring in 279 patients. The computer was not accurate in the middle group of patients with a predicted chance of survival between 10 and 59%. Only 26 patients fell in this group which did not permit differentiation between survivors and non-survivors. On the other hand, the computer was quite accurate in patients in the very poor risk category. The prediction was 85% correct in identifying such patients with less than a 10% chance of surivivng the operation.

TABLE 6. *Contribution of Each Variable in Predicting Survival*

Variable	313 Survivors	34 Non-survivors
Renal	3%	41%
Pulmonary	10%	62%
Age (years)	52 ± 11	67 ± 14
Emergency	30%	94%
Obstruction	18%	3%
Cardiovascular	8%	44%
Liver	5%	27%
Perforation	20%	38%
Intractability	30%	0%
Hemorrhage	43%	65%

Prospective Study

Beginning in January, 1975, a prospective study was initiated based on the computer analysis and the written program to predict survival in all patients undergoing surgery for complicated peptic ulcer disease. Preoperatively, each patient was analyzed by this quantitative program. In the 8 month period there have been 29 patients operated on for the complications of peptic ulcer disease in this hospital. As shown in Table 7, there were 22 patients in whom the preoperatively predicted survival figures ranged from 99 to 82%. All of these patients survived surgery and were discharged. In the 75–46% predicted survival group, there were only three patients and they all survived. However, there were 4 patients who died within 30 days following their surgery. The computer identified each of them quite accurately with the preoperative predicted survival values of 4, 2, 1, and 1% respectively. A brief case summary of each patient is presented to emphasize the seriousness of his illness.

Case Reports

Case 1. W. C., a 58-year-old Caucasian man, was a heavy alcohol consumer and smoker and had poor nutrition, severe cardiovascular and liver disease and moderate pulmonary complications. He had a perforated duodenal ulcer with infected ascites and was in shock. He was seen at 3:30 am, resusitated and underwent emergency surgery at 9:00 am. His predicted survival was 4%. Operation: Closure of perforated D.U.; course: Sepsis, fistula, renal failure, fluid balance difficulties, ascites. He died 15 days postop.

Case 2. O. L., a 77-year-old Caucasian man, had a poor nutritional status, gastric ulcer by endoscopy, moderate

pulmonary and severe cardiovascular disease, hemorrhage. He was operated on at 2:00 am after receiving 6 units of blood. His predicted survival was 2%. Operation: Vagotomy, antrectomy, Bilroth II for gastic and duodenal ulcers; course: Massive intra-abdominal hemorrhage from ulcer bed. He died 12 days postop.

Case 3. P. P., a 64-year-old Caucasian man with poor nutritional status, was a light alcohol consumer, heavy smoker, diabetic and had moderate pulmonary and renal complications, carcinoma of prostate, severe cardiovascular problems and a perforated ulcer. Emergency surgery was done. His predicted survival was 1%. Operation: closure of perforated D. U.; course: Cardiac death, 7 days postop.

Case 4. H. D., a 55-year-old Caucasian man, had a duodenal ulcer for 2 years. He was a heavy alcohol consumer, heavy smoker, in a poor nutritional state, and had moderate pulmonary, severe liver, severe renal complications and pancreatic ascites. Hemorrhage required 17 units of blood; failure of the arterial catheter to control hemorrhage resulted in emergency operation. His predicted survival rate was 1%. Operation: Vagotomy, pyloroplasty, oversewing D. U.; Course: Hypotension, cardiac arrest, death in O. R.

Discussion

This paper is not designed to discuss the relative values of the different surgical approaches used for the control of peptic ulcer disease patients. Indeed, elective vagotomy and drainage procedures and resections were done safely with an operative mortality of 1% which compares favorably with recently reported series advocating several procedures in a large number of patients.[1-5] On examining our data, it is also obvious that urgently ill patients undergoing either of these two procedures did not differ in their operative mortality, although patients with a greater risk of surgery, for the most part, had the less time-consuming operation. The fact remains that in this patient population, a great proportion of very severely ill patients underwent a surgical procedure for complications for peptic ulcer disease, and the survival of these patients was dependent more on their coexisting diseases, age and type of ulcer complication than on other factors.

The computer through its capability of statistically rating each one of these factors against each other and computing the probability of a patient surviving a surgical procedure gives us a new educational tool which has certain advantages. For the first time, we can accurately quantitate the risk of a necessary operation based on our previous operative experience. When a surgical trainee evaluates an older patient in the medical intensive care unit who has been on a respirator for long standing pulmonary disease, in renal failure and concomitantly develops hemorrhage from a long standing duodenal ulcer, the trainee can now alter his usual response of "a high risk patient but we will operate to stop his bleeding and maybe save his life" by accurately placing the risk of this patient surviving at only 1%. His judgment would be secure if he elected instead to attempt to stop his hemorrhage with a vasopressor from an indwelling arterial catheter or by other noninvasive methods. Chances of the patient surviving with medical therapy are probably as good as, or better without the added trauma of surgery since he is dying from his coexisting disease.

We can also use this computer analysis to educate our medical colleagues. It should be obvious that delay often exaggerates the risk in patients with peptic ulcer disease. Pointing out the risk factors shown in this analysis to even the most reluctant referring physician should encourage him to reconsider operating earlier and electively on his patients with intractable ulcer disease. A safe, definitive operation offering good control of the ulcer disease before the marked increase in risk that occurs in older patients with coexisting disease is warranted. On the other hand, the group of patients with chronic peptic ulcer disease, with or without associated medical complications, who have not and never will come to surgery for their ulcer disease far exceeds the number operated on either electively or as an emergency. The computer provides a tool which could result in patient selection for elective surgery on rational grounds, and through a prospective, randomized study the accuracy of this rationale can be determined.

The concept of using this type of computer analysis for predicting outcome can certainly be applied to many other surgical problems. In the case of a complicated peptic ulcer patient, such an evaluation is not meant to be the sole deciding factor of whether or not to operate. That decision is still based on subjective clinical judgment. However, it stands to reason that an objective, quantative assessment of a patient's chances of survival, based on the analysis of complications accompanying a disease entity, can only improve our clinical judgment.

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References

1. Eisenberg, M. M., Woodward, E. R., Carson, T. J. and Dragstedt, L. R.: Vagotomy and Drainage Procedure for Duodenal Ulcer: The Results of Ten Years' Experience. Ann. Surg., 170:317, 1969.
2. Herrington, J. L., Jr., Sawyers, J. L. and Scott, H. W.: A 25 Year Experience with Vagotomy—Antrectomy. Arch. Surg., 106:469, 1973.
3. Palumbo, L. T. and Sharpe, W. S.: Distal Antrectomy with Vagectomy for Duodenal Ulcer: Results in 611 Cases. Ann. Surg., 182:610, 1975.
4. Palumbo, L. T., Sharpe, W. S., Lulu, D. J., et al.: Distal Antrectomy with Vagectomy for Duodenal Ulcer. Arch. Surg., 100: 182, 1970.
5. Wolf, J. S., Bell, C. C., Jr. and Zimberg, Y. H.: Analysis of 10 Years' Experience with Surgery for Peptic Ulcer Disease. Am. Surg., 38:187, 1972.