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Original Article

Decision making in emergency laparotomy: the role of predicted life expectancy

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Abstract

Introduction: Increasing numbers of older patients are undergoing emergency laparotomy (EL). They are at increased risk of adverse outcomes, making the shared decision on whether to operate challenging. This retrospective cohort study aimed to assess the role of age and life-expectancy predictions on short- and long-term survival in patients undergoing EL.

Methods: All patients who underwent EL at one hospital in the West of Scotland between March 2014 to December 2016 were included. Clinical parameters were collected, and patients were followed up to allow reporting of 30-, 60- and 90-day and 1-year mortality rates. Period life expectancy was used to stratify patients into below life expectancy (bLEP) and at-or-above life expectancy (aLEP) groups at presentation. Remaining life expectancy was used to calculate the net years of life gained (NYLG).

Results: Some 462 patients underwent EL: 20 per cent in the aLEP group. These patients were older ($P < 0.001$), had more co-morbidities ($P < 0.001$) and were high risk on P-POSSUM scoring ($P = 0.008$). The 30-, 60- and 90-day and 1-year mortality rates were 11, 14, 16 and 23 per cent respectively. Advanced age ($P = 0.011$) and high ASA score ($P = 0.004$) and P-POSSUM score ($P < 0.001$) were independent predictors of death at 1 year on multivariable analysis. The cohort NYLG were 19.2 years. Comparing patients aged less than 70 with those aged 70 years or older, the NYLG were 25.9 *versus* 5.5 years. Comparing bLEP and aLEP, the NYLG were 22.2 *versus* 4.4 years. In patients aged 70 years and older, NYLG decreased by more than half in patients with co-morbidities (ASA score 3,4,5) (9.3 *versus* 4.3 years).

Conclusion: Discussions around long-term outcomes after emergency surgery remain difficult. Although age is an influencing factor, predicted life expectancy alone does not provide additional value to shared decision making.

Introduction

Increasing numbers of patients with advanced age are undergoing emergency laparotomy (EL)[1]. These older adults (70 years of age and older) make up around half of the cohort in the National Emergency Laparotomy Audit (NELA) and have a significantly increased risk of adverse outcomes and postoperative complications[2–11]. As a consequence, the shared decision regarding whether or not to operate in this group of patients is often challenging due to the need to balance the predicted therapeutic benefits of EL against the potential significant risks, which include death and a reduced quality of life[12]. With the added complexity that application of age alone may underestimate potential outcomes for a healthy older adult, it remains unknown whether evaluation of patients' predicted life expectancy could aid such decisions.

Life expectancy is a measure of the average time someone is expected to live and, in the UK, is calculated annually by the National Records of Scotland (NRS) and the Office of National Statistics (ONS). There are two different types of life expectancies: cohort and period[13,14]. Cohort life expectancy is calculated based on a combination of observed and predicted mortality rates, taking into account the changes in mortality rates throughout the lifetime of the cohort. For example, lifestyle behaviour changes and improved treatments could lead to improvements in cohort life expectancy, whereas a disease pandemic might lead to a reduction. In contrast, period life expectancy (PLE) assumes that the mortality rates stay constant throughout the remainder of a person's life. PLE is used by the ONS and NRS to demonstrate trends in life expectancy and to produce life tables for a cohort of individuals born and alive within a specific period of time (example shown in *Fig. S1*).

In addition to including life expectancy at birth (PLE), life tables predict the percentage of the population surviving to a particular year of age and subsequently, the remaining life expectancy (RLE) for people at different ages. For example, at emergency presentation, a 70-year-old male patient who resides in an area with a Scottish Index of Multiple Deprivation (SIMD)

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quintile of 1 (high deprivation score) has a PLE of 71.4 years (predicted life expectancy at birth). Interpretation of the life tables show that at the age of 70, he is one of 61 465 males (out of 100 000) that have reached this age, giving him a predicted RLE of 11.9 years. As a result, these life tables potentially allow quantification of years of life gained for patients considering undergoing EL. If such patients survive, these life tables may have a role in aiding shared decision making.

The aim of this study was to assess the role of age and life-expectancy predictions on short- and long-term survival in all patients undergoing emergency laparotomy.

Methods

The study has been reported using the STROBE guidelines[15]. All patients who underwent EL at one hospital in the West of Scotland between March 2014 and December 2016 were included. Patients were identified from a prospectively maintained database where local data are submitted centrally to the Scottish Government as part of their Modernising Patient Pathways Programme[16]. A standardized data collection pro forma was used[17]. A Caldicott Guardian and the research and development team of NHS Greater Glasgow and Clyde granted approvals for data usage.

Patient inclusion and exclusion criteria

Consecutive patients over the age of 18 who underwent EL were included according to the NELA inclusion criteria (*Appendix S1*)[18]. EL patients who had surgery for any condition related to the appendix or gallbladder, hernia repair with no bowel resection, trauma and planned return to theatre were excluded according to the NELA criteria.

Variables collected

The following clinical parameters were collected: age, sex, SIMD quintile[19], ASA score[20] and P-POSSUM score. Patients were followed up to allow reporting of 30-, 60- and 90-day and 1-year mortality rates.

For analysis, age was grouped into less than 70 years old (younger adults) and 70 years and over (older adults); ASA and SIMD quintiles were grouped into 1, 2 and 3, 4, 5 combined, to aid with statistical analysis. The use of P-POSSUM for risk prediction has been inconsistent within the literature, in particular overestimating risk in low-risk patients and the opposite for high-risk patients[21–25]. To overcome this limitation, patients were categorized into low- (less than 5 per cent) or high-risk (greater than or equal to 5 per cent) groups as per guidelines from the Royal College of Surgeons of England, so as to allow better identification of high-risk patients[10].

Socioeconomic deprivation has been associated with poorer postoperative outcomes[26]. SIMD is a deprivation score allocated to each of the 6976 data zones (similarly sized areas of approximately 760 people) in Scotland. Thirty-eight indicators of deprivation are grouped into seven domains to generate an SIMD, which is used to rank each data zone from one (most deprived) to 6976 (least deprived). This is further subcategorized into quintiles (one to five) and the postcode of individual patients was used to identify the corresponding SIMD quintile based on the latest index (SIMD 2016)[27].

Period life expectancy and remaining life expectancy

The PLE and RLE of each patient for a given age, sex and SIMD quintile were obtained from the 2014–2016 Scottish abridged life table as published by the NRS[14]. The authors used the Scottish life table as it provided age, sex, deprivation status-matched PLE and remaining years of life.

PLE was used to stratify patients based on their age at EL presentation into two groups: below life expectancy at presentation (bLEP) and at or above life expectancy at presentation (aLEP). Interpretation of the life tables allowed the use of RLE for each patient to calculate the net years of life gained (NYLG) for each patient who was alive at 1 year after EL (*Table 1*)[28].

NYLG is an objective measure of the true therapeutic benefit of EL as it accounts for the years of life lost from the procedure to arrive at a number for the true years of life gained for each EL performed.

For further analysis of NYLG, patients were categorized into subgroups based on: age less than 70 years *versus* greater than or equal to 70 years; age at presentation for EL in relation to their PLE; and the presence or absence of significant co-morbidities (ASA 1, 2 *versus* ASA 3, 4, 5).

Statistical analysis

Descriptive analysis of the cohort was reported. Pearson χ^2 test was used to assess the relationship between categorical variables and mortality rates. Univariable Cox proportional hazards regression analysis was performed on patient risk factors for death. Variables with $P < 0.100$ were subsequently included in multivariable analysis to identify independent predictors of death at 30, 60 and 90 days and 1 year. $P < 0.050$ was considered statistically significant in the multivariable analysis. Statistical analysis was performed using IBM SPSS™, version 23 (IBM Corp, Armonk, New York, USA).

Table 1 Calculation of net years of life gained from emergency laparotomy

	EL	EL patients alive at 1 year
Number	$a = \frac{\text{Total number of EL}}{\text{Number of EL patients alive at 1 year}}$	1
Average potential years of life gained	–	b
Average potential years of life lost	c	–
1-year mortality rate of EL	d	–
Years of life gained	–	e = 1 × b
Years of life lost	f = a × c × d	–
Net years of life gained	e–f	

a, the number of emergency laparotomy (EL) procedures performed for each patient alive at 1 year. **b**, average potential years of life gained (PYLG); PYLG was defined as the number of years of life gained if a patient was alive at 1 year after EL. **c**, average potential years of life lost (PYLL); PYLL was defined as the number of years of life lost if a patient was dead at 1 year after EL. **d**, 1-year mortality rate of EL (in specific cohorts). **e**, years of life gained. **f**, years of life lost (after accounting for number of EL performed for each patient alive at 1-year and mortality rate of EL). Net years of life gained = years of life gained (**e**) – years of life lost (**f**).

Table 2 Basic demographics of emergency laparotomy patients

Characteristics	Patients ($n = 462$)
Gender	
Female	242 (52.4)
Male	220 (47.6)
Age (years)	
<70	285 (61.7)
≥70	177 (38.3)
SIMD	
1	141 (30.5)
2	92 (19.9)
3	102 (22.1)
4	66 (14.3)
5	61 (13.2)
SIMD category	
Deprived (1, 2)	233 (50.4)
Non-deprived (3, 4, 5)	229 (49.6)
ASA score	
1	26 (5.6)
2	146 (31.9)
3	166 (35.9)
4	115 (24.9)
5	9 (1.9)
ASA category	
No co-morbidities (1, 2)	172 (37.2)
With co-morbidities (3, 4, 5)	290 (62.8)
P-POSSUM	
Low-risk (<5%)	200 (43.3)
High-risk (≥5%)	261 (56.5)

Values in parentheses are percentages.

Table 3 Mortality rates of emergency laparotomy patients

	Deaths			
	30-day	60-day	90-day	1-year
Overall ($n = 462$)	52 (11.3)	65 (14.1)	74 (16.0)	105 (22.7)
versus NELA	(9.5)	–	(12.9)	(23.2)
Age (years)				
<70 ($n = 285$)	24 (8.4)	29 (10.2)	34 (11.9)	44 (15.4)
≥70 ($n = 177$)	28 (15.8)	36 (20.3)	40 (22.6)	61 (34.5)
P	0.014	0.002	0.002	<0.001
Life expectancy at EL				
Below ($n = 369$)	36 (9.8)	44 (11.9)	51 (13.8)	72 (19.5)
At or above ($n = 93$)	16 (17.2)	21 (22.6)	23 (24.7)	33 (35.5)
P	0.042	0.008	0.010	0.001
Presence of co-morbidities in patients aged 70 years old and above				
ASA <3 ($n = 34$)	2 (5.9)	3 (8.8)	3 (8.8)	6 (17.6)
ASA ≥3 ($n = 143$)	26 (18.2)	33 (23.1)	37 (25.9)	55 (38.5)
P	0.077	0.063	0.033	0.022

Values in parentheses are percentages.

Results

Characteristics of emergency laparotomy patients

A total of 462 patients underwent EL during the study period (*Table 2*). The majority of patients were female (242 patients, 52.4 per cent), less than 70 years old (285 patients, 61.7 per cent) with 50.4 per cent coming from the most deprived areas (SIMD 1 or 2; 233 patients). More than half of the patients had co-morbidities (290 patients, 62.8 per cent) and were considered high risk (261 patients, 56.5 per cent). The 30-, 60- and 90-day and 1-year mortality rates of patients who had EL were comparable to those of NELA data, at 11.3, 14.1, 16.0 and 22.7 per cent respectively (*Table 3*).

Period life expectancy at presentation

Some 80 per cent of patients presented at an age below their PLE (369 patients; bLEP group) (*Table 4*). Comparison of the two groups found that patients in the aLEP group were older (100 per cent 70 years old or over, $P < 0.001$), more likely to present with co-morbidities (84.9 *versus* 57.2 per cent, $P < 0.001$) and more likely to be categorized as high risk (68.8 *versus* 53.5 per cent, $P = 0.008$).

Mortality rates

Patients with advanced age (70 years old and above) and those that presented at or above their PLE (aLEP) consistently reported greater short- and long-term mortality rates. The presence of co-morbidities in patients aged 70 years old and above was significantly associated with greater 90-day and 1-year mortality rates, but not greater 30- or 60-day mortality rates (*Table 3*).

High ASA and P-POSSUM scores were independently predictive of death at 30, 60 and 90 days and 1 year on multivariable analysis (*Table S1*). Advanced age was an independent predictor of death at 1 year (hazard ratio 1.88, 95 per cent c.i. 1.16 to 3.05, $P = 0.011$), after adjusting for ASA ($P = 0.004$) and P-POSSUM score ($P < 0.001$).

Potential years of life gained and lost and net years of life gained

The calculation of the mean NYLG for each patient's death avoided (alive at 1 year) through EL is shown in *Table S2*. For each patient alive at 1 year after EL (357 patients), an average of 1.29 cases of EL (462 patients) was performed. EL was associated with a 1-year mortality rate of 22.7 per cent and an average potential years of life lost (PYLL) of 17.1 years for each death at 12-months' follow-up in this cohort. This amounted to 5.0 years of life lost, which was then subtracted from an average potential years of life gained (PYLG) of 24.3 years, resulting in a net gain of 19.2 years of life for each patient alive at 1 year after EL.

Potential years of life gained and lost and net years of life gained stratified by age at presentation

The difference between the patients aged under 70 years and patients 70 years old and over is shown in *Table S3*. Patients under 70 had an average PYLG of 30.6 years, three times that of older patients. This resulted in a much greater NYLG in younger patients when compared with that of patients aged 70 and above (25.9 years *versus* 5.5 years). The NYLG reduced further in patients aged 80 years old and over to 3.7 years.

Potential years of life gained and lost and net years of life gained stratified by period life expectancy at presentation

The bLEP patients had a much greater PYLG and PYLL (27.4 and 21.3 years respectively) compared with aLEP patients (8.8 and 7.9 years respectively), hence the greater NYLG in bLEP patients (22.2 *versus* 4.4 years) (*Table S4*).

Potential years of life gained and lost and net years of life gained stratified by the presence of co-morbidities

The effect of co-morbidities on the NYLG was compared in older patients (over 70 and over 80 years old) (*Table S5*). In patients aged 70 and above, the PYLG was similar regardless of the presence of co-morbidities (12.1 *versus* 10.9 years). However, the NYLG decreased by more than half in patients with co-morbidities (4.3

Table 4 Basic demographics of emergency laparotomy patients subdivided by their period life expectancy (using age at presentation)

Characteristic	Patients		P
	Below life expectancy ($n = 369$)	At or above life expectancy ($n = 93$)	
Gender			
Female	192 (52.0)	50 (53.8)	
Male	177 (48.0)	43 (46.2)	0.765
Age (years)			
<70	285 (77.2)	0 (0.0)	
≥70	84 (22.8)	93 (100.0)	<0.001
SIMD category			
Deprived (1, 2)	180 (48.8)	53 (57.0)	
Non-deprived (3, 4, 5)	189 (51.2)	40 (43.0)	0.157
ASA category			
No co-morbidities (1, 2)	158 (42.8)	14 (15.1)	
With co-morbidities (3, 4, 5)	211 (57.2)	79 (84.9)	<0.001
P-POSSUM			
Low risk (<5%)	171 (46.5)	29 (31.2)	
High-risk (≥5%)	197 (53.5)	64 (68.8)	0.008

Values in parentheses are percentages.

versus 9.3 years). A similar result was observed in patients aged 80 and above, with a NYLG of only 3.1 years in patients with co-morbidities.

Discussion

Acknowledging that age is an influencing factor, this study explored the potential role of using age and PLE to predict long-term mortality rates in patients undergoing EL so that it could be used as an adjunct for decision making for EL. Twenty per cent of patients presented above their PLE with nearly 65 per cent being alive 1 year later. Undergoing EL at any age was associated with net years of life gained, however this gain reduced with increasing age. With physiological factors found to be independent of age, this work shows that whilst age and PLE can guide short- and long-term mortality outcomes, they are not reliable nor are they absolute discriminators, limiting their utility in aiding decision making in the emergency setting.

The perioperative team's decision to operate and subsequent levels of care can be based on numerous factors, including the patient's fitness based on scoring systems (for example, NELA risk score), frailty[29], age, the presence of co-morbidities and objective markers of physical health[30]. It is rarely based on one solitary factor and can be especially challenging in the time-pressured emergency surgery setting. In this study, co-morbidities and being classified as high risk were shown again to be independent predictors of increased mortality rate[31,32]. The negative influence of increasing age was also confirmed with patients over the age of 70 doubling their short- and long-term mortality rates compared with those of adults under 70 years old. It is likely that those poorer older-adult outcomes were not a result of age per se but reflect a greater prevalence of co-morbidity in older age groups: a 1-year mortality rate of 34.5 per cent increased to 38.8 per cent if two or more co-morbidities were present. A recent study characterized an alternative group of patients who fulfil criteria for EL but who do not proceed to surgery, the 'NoLap' cohort[33]. These patients make up one-third of admissions with an acute surgical abdomen and up to 30 per cent of these patients are alive 30 days after admission. Surgery is deemed futile in these patients, either due to poor fitness or advanced malignancies. This alternative should be taken into consideration when deciding whether to operate or not, as elderly patients with limited physiological reserve will have a shorter life expectancy and potentially a poorer quality of life with postoperative complications.

In this study the influence of age was explored further by applying life expectancy predictions accompanied by estimates of years of life gained and lost. The results found that PLE using data from national audits cannot be applied in emergency surgical decision making as one fifth of patients present above their PLE. In addition, a significant number survive despite having higher ASA scores and greater co-morbidity than those that present before their PLE. The potential role of NYLG was then explored using life tables, finding that all age groups had predicted net gains in years of life. Clearly this limits the clinical applicability of life tables in the emergency surgical setting.

Findings from this study support the discussion of the influence of age and life expectancy in the general context of an increased risk of mortality with older patients. However, greater consideration should be given to the physiological and physical fitness of the individual older adult when deciding on both treatment options and possible long-term outcomes. Indeed, with high-risk patients and those with with co-morbidities being at greatest risk, alternative prognosticators to age, such as frailty, should be integrated in the EL setting[29].

Gained net years after EL seems like a positive outcome, however, it is not clear what those predicted gains mean for the day-to-day living of individual patients. The possibility of recurrent readmissions or clinic attendances or increasing care/nursing home to overcome reducing independence are not considered in this study, but have been reported as important outcome measures expressed by patients that have undergone EL[12]. With NELA initially focusing on reducing mortality rates, consideration to long-term patient needs, including quality of life, is an unexplored and clearly needed, research area.

Although this study is limited by being a single-centre study with a relatively small cohort compared with national audits, the patients have similar baseline characteristics and mortality rates to NELA, hence generalizability of the results. It is acknowledged that alternative methods for the calculation of NYLG are available and may offer improved insights; this is, however, an evolving area that is still poorly understood.

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Supplementary material

Supplementary material is available at *BJS Open* online

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