Postoperative complications and mortality in older patients having non-cardiac surgery at three Melbourne teaching hospitals

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ABSTRACT

Objective: To determine the incidence of postoperative complications, including 30-day mortality rate, and need for intensive care unit (ICU) admission in older patients after non-cardiac surgery.

Design and setting: Prospective observational study of all patients aged 70 years or older having elective and non-elective, non-cardiac surgery, and staying at least 1 night after surgery in one of three Melbourne teaching hospitals, June to September 2004.

Main outcome measures: Postoperative complications and 30-day mortality rate.

Results: 1102 consecutive patients were audited in mid 2004; 70% had pre-existing comorbidities. The 30-day mortality rate was 6%; 19% had postoperative complications; and 20% of patients spent at least 1 night in ICU. On multivariate analysis, preoperative factors associated with 30-day mortality included age (odds ratio [OR], 1.09 per year over 70 years; 95% CI, 1.04–1.13; $P < 0.001$); increasing severity of systemic disease (American Society of Anesthesiologists physical status classification) (OR, 2.53; 95% CI, 1.65–3.86; $P < 0.001$); and albumin level < 30 g/L (OR, 2.23; 95% CI, 1.09–4.57; $P = 0.03$). Postoperative factors associated with 30-day mortality were unplanned ICU admission (OR, 3.95; 95% CI, 1.63–9.55; $P = 0.003$); sepsis (OR, 2.75; 95% CI, 1.17–6.47; $P = 0.02$); and acute renal impairment (OR, 2.40; 95% CI, 1.06–5.41; $P = 0.04$). Thoracic surgery was the only surgical specialty significantly associated with mortality (OR, 3.96; 95% CI, 1.44–9.10; $P = 0.008$) in the multivariate analysis.

Conclusion: Older patients having surgery had high rates of comorbidities and postoperative complications, placing considerable demands on critical care services. Patient factors were often stronger predictors of mortality than the type of surgery.

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Little is known about the incidence and extent of comorbidities and complications in older Australians having surgery or the mortality associated with surgery.[1] A recent Western Australian study of patients who died after surgery found that most were old and had complex comorbidities.[2] Studies in North America and Europe have assessed postoperative outcomes for older patients in several surgical specialties.[3-7] The most extensive data come from the National Surgical Quality Improvement Program (NSQIP) of the Department of Veterans Affairs in the United States. Using the NSQIP database, Hamel et al recently described risk factors for mortality in over 25 000 patients aged 80 years or older.[4] Whether their findings apply to Australia is unclear (it is a US database of patients with previous military service, 98% are men, and many come from disadvantaged backgrounds).[8]

Major complications after surgery are strongly associated with prolonged hospitalisation, increased hospital costs, and mortality.[9] There are emotional, social and economic costs to the patient, their family and society. Repeat hospitalisation and long-term disability may result. Indeed, in some cases, there may be reason to question the net benefit of surgery.

We therefore performed a prospective observational study of patients 70 years and older having surgery at three Melbourne hospitals to test the hypothesis that morbidity and mortality rates in older patients after surgery are high, resulting in a significant workload burden on hospital critical care services.

METHODS

Our study was conducted simultaneously at three university-affiliated Melbourne hospitals — Austin Health, the Royal Melbourne Hospital, and the Alfred Hospital — between June and September 2004. Each hospital's human research ethics committee approved the study and waived the need for informed consent from individual patients for this audit.

We studied consecutive patients aged 70 years or older undergoing elective and non-elective, non-cardiac surgery, who were expected to require at least overnight hospitalisation. Surgical specialties were classified as in other Australian surgical audits.[2] A research nurse at each hospital identified patients from operation lists, operating room records, and surgical unit liaison nurses. Data were collected prospectively for the first 5 days after surgery, or until hospital discharge (whichever was longer), both in the intensive care unit (ICU) and the general wards. At all three hospitals, the ICU included a high dependency unit.[10] With planned ICU admissions, admission was planned before surgery, and all other ICU admissions were unplanned, including when the decision to admit to ICU was made during or after the surgical procedure.

We collected data on preoperative comorbidities,[11,12] serious complications developing during or after surgery, and 30-day mortality.[9,12] Non-elective surgery was an operation added to a routine elective operating list or done after-hours. The American Society of Anesthesiologists physical status (ASA status) classification of severity of systemic disease was used as a general marker of comorbidity. Our definitions of serious complications (see Appendix, *page 451*) were based on those used in our previous studies.[9,11-13] Mortality data were collected daily on weekdays during hospitalisation, as well as from the medical record, or by telephone follow-up at 30 days.

Statistical analysis

Data were de-identified at each site and stored in a computer spreadsheet (Excel 2000, Microsoft, Redmond, Wash, USA), with descriptive data generated using summary statistics. We compared the relationship between 30-day mortality and preoperative comorbidities, postoperative complications, and factors related to surgical specialty, using Fisher's exact tests (GraphPad Prism, version 4; GraphPad Software Inc, San Diego, Calif, USA). Comparisons of

1 Thirty-day mortality rate and complications, by type of surgery ($n = 1102$)

Surgery	No. (%) of patients	Complications, % (complications/ 100 patients)	Mortality rate	Odds ratio (95% CI)	*P*
ENT; faciomaxillary	51 (5%)	10% (24)	6%	1.1 (0.3–3.3)	0.91
Colonic	58 (5%)	28% (59)	5%	0.9 (0.3–2.9)	0.90
General	213 (19%)	22% (33)	7%	1.3 (0.7–2.3)	0.46
Neurosurgery	118 (11%)	18% (30)	6%	1.1 (0.5–2.4)	0.84
Orthopaedic, hip and knee	189 (17%)	21% (31)	5%	0.9 (0.5–1.9)	0.87
Orthopaedic, other	69 (6%)	19% (33)	3%	0.5 (0–1.9)	0.32
Plastic	59 (5%)	14% (20)	3%	0.6 (0–2.2)	0.46
Thoracic	44 (4%)	18% (39)	16%	3.5 (1.5–8.1)	0.002
Urology	136 (12%)	13% (20)	2%	0.4 (0.1–1.1)	0.07
Arterial vascular	71 (6%)	18% (42)	10%	1.9 (0.9–4.4)	0.09
Other vascular	83 (8%)	17% (27)	2%	0.4 (0–1.5)	0.19
Other	11 (1%)	10% (10)	1%	1.7 (0–10.6)	0.6

ENT = ear, nose, and throat. ◆

patients dying by Day 30 with those surviving more than 30 days were done using *t*-tests or Mann–Whitney *U* tests (Stata, version 9.1; Stata Corporation, College Station, Tex, USA). Univariate predictors of 30-day mortality were entered into forward, stepwise, multivariate logistic regression analyses of combined pre- and postoperative factors, including age and sex (Stata, version 9.1). Interaction terms were not explored. A *P* value of less than 0.05 was considered statistically significant.

RESULTS

There were 1102 patients who matched our criteria (age ⩾ 70 years, non-cardiac surgery and overnight stay). Their median age was 77 years (range, 70–104 years); 48% were women. The surgical procedures they underwent are listed in Box 1. Deaths and postoperative complications occurred in most surgical specialties. Patients having thoracic surgery had the highest 30-day mortality rate (Box 1).

Twenty-one patients (2%) died within the first 5 days after surgery, and 61 died by 30 days (30-day mortality rate, 6%). Within the first 5 days after surgery, complications occurred in 208 patients (19%). These 208 patients had a total of 344 complications — an overall rate of 31 complications per 100 patients. Patients suffering at least one complication stayed in hospital for a median of 13 days (interquartile range [IQR], 7–27 days), while those without complications stayed a median of 7 days (IQR, 3–14 days) (median difference, 5 days; 95% CI, 4–7 days; $P < 0.001$).

Patients who died by Day 30 tended to be older and more seriously ill, and had more complications and a longer hospital stay (Box 2). The sex of the patient was not a factor in determining mortality rate (Box 2 and Box 3). Seventy per cent of patients had at least one comorbidity before surgery; almost 70% were graded as ASA status 3–5 (ie, severe systemic disease to moribund); and about a quarter had non-elective surgery (Box 3).

In a forward, stepwise, multivariate analysis, independent preoperative factors associated with 30-day mortality included:

- age (odds ratio [OR], 1.09 per year over 70 years; 95% CI, 1.04–1.13; $P < 0.001$);
- increasing severity of systemic disease (indicated by ASA status level) (OR, 2.53; 95% CI, 1.65–3.86; $P < 0.001$); and
- albumin level < 30 g/L (OR, 2.23; 95% CI, 1.09–4.57; $P = 0.03$).

Postoperative factors associated with 30-day mortality included:

- unplanned ICU admission (OR, 3.95; 95% CI, 1.63–9.55; $P = 0.003$);
- sepsis (OR, 2.75; 95% CI, 1.17–6.47; $P = 0.02$); and
- acute renal impairment (OR, 2.40; 95% CI, 1.06–5.41; $P = 0.04$).

We excluded cardiac arrest from the analysis because the numbers were small (three patients). The only surgical specialty significantly associated with mortality in the multivariate analysis was thoracic surgery (OR, 3.96; 95% CI, 1.44–9.10; $P = 0.008$).

There were 202 patients (20%) admitted to ICU (or a high dependency unit) during the first 5 postoperative days. The admission for 75% of these patients was planned and in 25% it was unplanned. Of 52 unplanned ICU admissions, 21 had had general or colorectal surgery; 10 orthopaedic; seven vascular; four urological; four neurosurgery; three thoracic; two ear, nose and throat; and one had had plastic surgery.

DISCUSSION

In these patients 70 years and older undergoing non-cardiac surgery, 19% developed a complication within 5 days of surgery and 6% died within 30 days of surgery. Of those with a complication, 12% died within 30 days. The type of surgery (with the exception of thoracic surgery) was a weaker predictor of mortality than patient factors. Older age was an important predictor of 30-day mortality: by age 80 years, the risk of death doubled from age 70 years and it doubled again between 80 and 90 years.

Our findings are consistent with recent North American and European studies.[3-6] In the NSQIP,[4] which included an older (⩾ 80 years) and mostly male population (98%

2 Comparison of patient survival (> 30 days versus ⩽ 30 days)

	Survival (days)		
	> 30	⩽ 30	*P*
Patients	1041 (94%)	61 (6%)	
Age, median (IQR) years	77 (74–82)	81 (75–86)	0.002
Women	55%	53%	0.8
Unscheduled surgery	10%	49%	0.0001
Physical status*			
ASA 1, 2	28%	6%	< 0.001
ASA 3	56%	49%	
ASA 4	15%	40%	
ASA 5	1%	5%	
Comorbidities			
0	31%	12%	0.001
1	30%	25%	
2	21%	19%	
⩾ 3	18%	44%	
Complications			
⩾ 1	17%	51%	0.001
Length of stay, median (IQR) days	8 (4–16)	11 (5–25)	0.046

* American Society of Anesthesiologists (ASA) physical status classification (see Appendix).
IQR = interquartile range. ◆

3 Univariate analysis of the association between 30-day mortality and comorbidities and complications

	No. (%) of patients	Mortality rate	Odds ratio (95% CI)	*P*
Preoperative variable				
Age, per year > 70 years			1.1 (1.0–1.1)	< 0.001
Men	573 (52%)	6%	1.1 (0.6–1.8)	0.8
Ischaemic heart disease	149 (14%)	6%	1.1 (0.5–2.3)	0.77
Renal impairment	214 (19%)	9%	1.9 (1.1–3.4)	0.02
Diabetes	213 (19%)	5%	0.9 (0.5–1.8)	0.79
Cardiac failure	102 (9%)	9%	1.8 (0.9–3.6)	0.13
Respiratory insufficiency	89 (8%)	10%	2.1 (1.0–4.3)	0.05
Aortic stenosis	20 (2%)	0	—	—
Obesity	46 (5%)	4%	0.8 (0–2.9)	0.72
Cerebrovascular disease	135 (12%)	7%	1.3 (0.6–2.6)	0.53
Cognitive impairment	127 (12%)	9%	1.8 (0.9–3.4)	0.10
Albumin level < 30 g/L	108 (10%)	17%	4.0 (2.2–7.3)	< 0.001
Non-elective surgery	298 (27%)	10%	2.8 (1.7–4.7)	< 0.001
Physical status*				
ASA 1, 2	270 (24%)	1%	1.0	—
ASA 3	570 (52%)	5%	4.6 (1.4–15.1)	0.01
ASA 4	162 (15%)	14%	14.6 (4.3–49.4)	< 0.001
ASA 5	13 (1%)	23%	26.4 (4.8–147.5)	< 0.001
Postoperative variable				
Acute myocardial infarction	20 (2%)	30%	8.0 (3.1–20.9)	< 0.001
Cardiac arrest	3 (< 1%)	66%	35.3 (4.5–∞)	< 0.001
Reintubation	23 (2%)	17%	3.8 (1.3–10.9)	0.01
Acute pulmonary oedema	39 (4%)	15%	3.3 (1.4–8.1)	0.006
Pulmonary embolism	1 (< 1%)	0	—	—
Stroke	0	0	—	—
Wound infection	8 (< 1%)	25%	5.8 (1.1–26.0)	0.02
Return to operating theatre	34 (3%)	18%	3.9 (1.6–9.7)	0.002
Acute renal impairment	79 (7%)	16%	4.0 (2.1–7.7)	< 0.001
Sepsis	60 (5%)	20%	5.1 (2.6–10.1)	< 0.001
Unplanned admission to ICU	52 (5%)	21%	5.4 (2.6–10.9)	< 0.001

* American Society of Anesthesiologists (ASA) physical status classification (see Appendix).
ICU = intensive care unit. ◆

men), the postoperative complication rate was 25% and the 30-day mortality rate was 8%. Another US study of 544 patients aged 70 years or more found a postoperative complication rate of 20% and an in-hospital mortality rate of 4%.[5] The in-hospital mortality rate found in an Italian study[3] of patients aged 65 years or over was also 4%.

Among the comorbidities, we found that increasingly severe systemic disease (higher ASA level) and a low plasma albumin level (< 30 g/L) were important predictors of 30-day mortality. The risk of 30-day mortality almost doubled with each higher ASA status level. The ASA physical status classification is a measure of the overall severity of systemic disease and has long been used to assess perioperative risk.[14] Because ASA status covers all systemic diseases, it is a measure of cumulative risks from individual medical problems, such as ischaemic heart disease and renal impairment. Our findings support the validity of this classification as a marker of postoperative risk in an older Australian population. Decreased plasma albumin level can be a measure of chronic disease or malnutrition.[15] The predictive value of this frequently measured clinical chemistry variable for postoperative mortality[15] has been underused in preoperative assessment.[16] Furthermore, patients with a low albumin level may benefit from optimal preoperative nutrition.[8]

We found that patients having thoracic surgery had the highest mortality rate; this was also found by the NSQIP.[4] The reason for this is likely to be multifactorial, including the nature of the surgery as well as patient factors, but requires further study. A retrospective observational study of 8500 patients in Texas[8] found that only the most complex surgery, such as the Whipple procedure, increased risk attributable to patient factors (ASA class and albumin level) in perioperative risk estimation. Rather than downplaying the importance of type of surgery, this finding may well highlight the quality of operative care in Australia and the US.[8] We were unable to assess the relative risk of specific types of operations. To assess risks for Australian patients for specific operations, researchers will need to study large numbers of patients within surgical specialties and include independent risks, such as those found in our study.

One preoperative factor that was important in the univariate, but not the multivariate, analysis was non-elective surgery. Non-elective operations included semi-urgent and emergency surgery. Other studies have found emergency surgery to be an important predictor of mortality in older patients.[3-5,9] This discrepancy may be, firstly, because more non-elective surgery may have been semi-urgent rather than truly emergency surgery (unfortunately, we do not have accurate data on this); and, secondly, because older age and comorbidity were closely associated with non-elective surgery in the multivariate analysis. Thus, older, more seriously ill patients were more likely to be operated on in more urgent circumstances, as has been found by others.[3] Of our patients aged less than 80 years, 22% had non-elective surgery, whereas 36% of those aged 80 years and over had non-elective surgery; of those aged 80 years and over with ASA status 4 (significant systemic disease), 48% had non-elective surgery.

We found that many of the 19% of patients with postoperative complications had more than one complication: a rate of 31 complications per 100 patients. This compares with 23 complications per 100 patients found in a previous study of adult patients of all ages, using identical definitions and methods.[17] We found that unplanned ICU admission, sepsis, and renal

impairment were important postoperative predictors of death. Unplanned ICU admission was the strongest postoperative predictor. This variable is not measured in the NSQIP database,[4] but in a recent Australian study it was found to be a valid indicator of perioperative patient safety.[18] Our definitions of sepsis and renal impairment (see Appendix, *page 451*) included patients with mild-to-moderate disease.[19,20] Sepsis and renal impairment in many patients with relatively mild manifestations may have gone unnoticed by medical and nursing staff.[1] Systemic inflammation may be due to the effects of surgery, anaesthesia, or infection.[21,22] Strategies to minimise inflammation include optimal surgical technique,[21] and, possibly, pharmacological strategies, such as β-blockers and statins.[23] For postoperative renal impairment, apart from adequate hydration and haemodynamic stability, there are currently no clear preventive strategies.[24]

During the first 5 postoperative days, 222 patients (20%) spent at least 1 night in ICU: 15% planned and 5% unplanned. The unplanned admissions were spread across the surgical specialties. In 2002–2003, across Australia, 5% of all inpatients (excluding day-stay patients) were admitted to ICU.[10] Our study suggests that, proportionally, older surgical patients place considerable demands on ICU resources. Moreover, a third of all complications occurred in ICU, which added to the ICU workload. The overall hospital workload was increased by the patients with one or more complications, whose hospital stay was on average 5 days longer than those without complications.

System strategies that aim to optimise patients' condition before surgery and prevent or at least adequately treat complications may improve patient outcomes.[25] Such strategies often require both problem detection and problem response mechanisms.[26] One system change could be co-management of older surgical patients by doctors specialising in hospital medicine (hospitalists),[27] who ideally have skills in resuscitation, acute pain management, and general medicine. An Australian before-and-after study[28] found that co-management of patients with hip fracture by orthopaedic and geriatric specialists was associated with a 20% decrease in complications and a 3% decrease in mortality. A randomised, controlled study in the US[29] found orthopaedic–hospitalist co-management of patients having elective joint replacement was associated with a 12% decrease in complications. Both studies emphasised the need for frequent ward rounds to detect and respond to problems. Another method for better detection of problems on the wards is nurse-led critical care outreach,[26,30] with a critical-care trained nurse reviewing high-risk patients on general wards. In a recent Australian before-and-after study, this was shown to improve postoperative surveillance.[13]

The ICU-based, doctor-led, medical emergency team (MET) can be used to resuscitate surgical patients showing early signs of physiological instability.[26] A before-and-after study in Melbourne found that use of a MET was associated with a decrease in postoperative complications and mortality.[1] An observational study in Newcastle[31] found that co-management of MET calls by surgeons enhanced patient management. Further, a recent UK editorial suggested that surgeons should consider surgical causes for sepsis in patients developing arrhythmias after non-cardiothoracic surgery.[32]

The major strengths of our study are that it includes prospective, consecutive data for all eligible patients in three hospitals having a wide variety of operations, and uses a comparable classification to other Australian surgical audits.[2] Ours is the largest of the few studies conducted in Australia[1] and one of the few worldwide. While the hospitals are all in Melbourne, they have differences in mix of type of surgery, patient demographics, and approaches to issues such as use of a MET.[1] One limitation is that some surgical specialties were under-represented, particularly gynaecology. Another is that we do not have a parallel group of patients (eg, those aged 40–65 years) for comparison.[4] In some of the smaller subgroups, the confidence intervals are wide, but the odds ratios are comparable to those in the NSQIP.[4] Our results may not be able to be generalised to other hospitals, particularly smaller metropolitan and regional hospitals, but are similar to those from North American and European centres.[3-7]

In summary:

- After surgery, Australians aged 70 years and older were found to have a high mortality rate and to experience considerable morbidity, placing substantial demands on critical care services.
- Patient factors were, in most cases, more important than type of surgery for predicting mortality.
- Older age and more severe systemic disease (increasing ASA status level) were useful preoperative predictors of adverse outcomes.
- Plasma albumin level should be measured routinely before surgery, and this variable should be more widely used in preoperative assessment and management.
- Better detection of postoperative complications, including the early manifestations of sepsis and renal impairment, is warranted.[1,33]
- Management strategies require further study but may include system changes such as co-management of older patients having surgery with hospitalists,[34] nurse-led critical care outreach,[17] and greater use of METs.[26]
- ASA status level and unplanned ICU admission should become routine variables in all anaesthesia and surgical audits.[18,35]

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COMPETING INTERESTS

None identified.

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Appendix

Preoperative comorbidities

1. **Myocardial ischaemia** — documented history, within 2 years, of a positive result of an exercise test or thallium scan or a documented history of exertional angina. Excludes patients with angioplasty or coronary artery bypass grafting within 2 years without ongoing ischaemia
2. **Renal impairment** — serum creatinine level ⩾ 130 µmol/L
3. **Diabetes mellitus**
4. **Cardiac failure** — documented symptoms and signs of left or right heart failure when taking medication for heart failure, or measured left ventricular ejection fraction of ⩽ 35% within the past 2 years, or at least moderate left ventricular heart failure on echocardiogram
5. **Respiratory insufficiency** — PaO_2 ⩽ 60 mmHg on room air or $PaCO_2$ ⩾ 45 mmHg, or obstructive disease ($FEV_{1.0}$ ⩽ 1.0, or $FEV_{1.0}$/VC ratio ⩽ 0.30), or restrictive disease (VC ⩽ 1.0, or VC ⩽ 50% of predicted), or an admission (within 2 years of surgery) for acute respiratory failure requiring non-invasive or invasive ventilation
6. **Aortic stenosis** — documented valve area of ⩽ 1.5 cm^2 or peak gradient of ⩾ 30 mmHg
7. **Obesity** — body mass index ⩾ 30 kg/m^2
8. **Cerebrovascular disease** — stroke or transient ischaemic attacks
9. **Cognitive impairment** — documented impaired short-term memory or abnormal cognition affected, or Mini Mental State Examination score less than 24/30, or taking donepezil or galantamine
10. **Low plasma albumin level** — < 30 g/L
11. **American Society of Anesthesiologists (ASA) physical status**
    - **ASA 1:** normal, healthy patient
    - **ASA 2:** patient with mild systemic disease
    - **ASA 3:** patient with severe systemic disease
    - **ASA 4:** patient with severe systemic disease that is a constant threat to life
    - **ASA 5:** moribund patient who is not expected to survive without the operation

$FEV_{1.0}$ = forced expiratory volume in 1 s.
VC = vital capacity.
V/Q = ventilation–perfusion ratio.

Postoperative complications

1. **Acute myocardial infarction** — at least two of:
   - New onset or worsening of ischaemic symptoms (eg, chest pain, shortness of breath) lasting longer than 20 min;
   - Changes on the electrocardiogram consistent with ischaemia, including:
     - acute ST elevation followed by the appearance of Q waves or loss of R waves
     - new left bundle branch block
     - new persistent T wave inversion for at least 24 hours
     - new ST segment depression which persists for at least 24 hours
   - A raised troponin level or a peak creatine kinase MB fraction > 4% of an elevated total creatine kinase level, with characteristic rise and fall
2. **Cardiac arrest** — documented sudden cessation of cardiac output maintaining effective circulation
3. **Reintubation**
4. **Acute pulmonary oedema** — respiratory compromise with chest x-ray showing extravascular fluid in lung tissues and alveoli
5. **Pulmonary embolus** — high probability of embolism on V/Q scan *or* pulmonary angiogram
6. **Stroke** — confirmed by computed tomography scan, and clinical symptoms such as paralysis, weakness or speech difficulties, first documented after operation
7. **Sepsis (systemic inflammatory response syndrome)** — new finding of at least two of:
   - temperature, > 38.3°C, or < 36°C
   - white cell count, > 12×10^9/L
   - respiratory rate, > 20 breaths/min
   - heart rate, > 90 beats/min *or*
   - a positive result of a blood culture alone
8. **Wound infection** — purulent discharge or redness, or serous discharge *and* positive result of culture or having antibiotic treatment
9. **Unplanned return to operating room** — related to the surgery (eg, surgical bleeding)
10. **Acute renal impairment** — increase in serum creatinine level > 20% of preoperative value, or admission to intensive care unit for renal replacement therapy
11. **Unplanned admission** — to intensive care unit, coronary care unit or higher dependency unit
12. **Death** ◆

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