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Population outcomes, trends and the future of pouch surgery for ulcerative colitis: a 19-year New South Wales data linkage study

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Abstract

Background: Ileal pouch-anal anastomosis (IPAA) is considered the gold standard reconstructive option in ulcerative colitis (UC). Recent efforts to improve pouch outcomes have seen a push towards centralisation of surgery. This study aimed to document outcomes following pouch surgery at a population level within New South Wales (NSW), and identify factors associated with, and temporal trends of these outcomes.

Methods: A retrospective data linkage study of the NSW population over a 19-year period was performed. The primary outcome was pouch failure in patients with UC who underwent IPAA. The influence of hospital level factors (including annual volume) and patient demographic variables on this outcome were assessed using Cox proportional hazards modelling. Temporal trends in annual volume and evidence for centralisation over the studied period were assessed using Poisson regression analysis.

Results: The annual volume of UC pouches reduced over the study period. The pouch failure rates were 8.6% (95% CI 6.3–10.8%) and 10.6% (95% CI 8.0–13.1%) at 5- and 10-years, respectively. Increasing age and non-elective admission were associated with higher failure rates. One-third of UC pouches (31.6%) were performed in a single institution, which averaged 6.5 pouches/year throughout the study period. Three-quarters (19/25) of NSW public hospitals who performed pouches performed less than one UC pouch annually.

Conclusions: The outcomes following UC pouch surgery in NSW are comparable with global standards. Concentrating IBD pouch surgery with the aim of producing specialist surgical teams may be a reasonable way forward in NSW and would ensure equity of access and facilitate research and training collaboration.

Introduction

Ileal pouch-anal anastomosis (IPAA) was first described in 1978 and has progressively been adopted in Australia since the 1980s.[1] It is considered the gold standard reconstructive option in ulcerative colitis (UC), is associated with satisfactory long-term patient outcomes, and has been shown to improve quality of life.[2,3] While pouch surgery for UC has a low mortality rate, the rate of postoperative morbidity is high, with early hospital readmission required in up to one-quarter of patients.[4–8] Additionally, pouch failure requiring pouch excision or permanent diversion may be required, with pooled long-term failure rates of 7.7% and 10.3% at ≥5 and ≥ 10 years previously documented, respectively.[9]

Factors including advanced surgical experience and higher surgical volume have been shown to positively influence postoperative outcomes internationally. This has led to the development of various surgical quality of care standards to optimize patient outcomes.[10–12] Moreover, large population level studies from Europe (including the UK) and North America have demonstrated that a significant proportion of hospitals are performing very low

numbers of pouch reconstructions.[5–7,13–15] This has led to greater awareness of the need to accurately audit inflammatory bowel disease (IBD) patient outcomes at a national level. Recent guidelines for the accreditation of pouch units published in 2023 by the Association of Coloproctology of Great Britain and Ireland (ACPGBI), include a recommendation that units should perform more than five cases per year on a 5 year rolling basis.[16]

To date, the outcomes following IBD pouch reconstruction in Australia have only been reported in high-volume centres.[17–21] While these outcomes compare favourably with international specialist centres, very little is known about patient outcomes in lower volume centres or at a population level within Australia. Administrative data sets provide the opportunity to assess real world outcomes at a population level and have been a valuable tool to assess both regional variation and the volume outcome relationship outside Australia.[13,22] They also avoid recall bias inherent with voluntary data sets. Therefore, this study aimed to comprehensively assess the trends and outcomes for patients undergoing UC pouch reconstruction in New South Wales (NSW) using population data over the past two decades.

Methods

Data source

The Admitted Patient Data Collection (APDC), Registered Birth Death and Marriages (RBDM) and Cause of Death Unit Record Files (COD URF) data sets from NSW Australia were linked using probabilistic linkage. The APDC data set contains information on inpatient separations (discharges, transfers, or deaths) from all public hospitals (with the exception of the Northern Beaches hospital since October 2018), private hospitals, and private day procedure centres in NSW from 1 July 2001. De-identified data were linked by the NSW Ministry of Health Centre for Health Record Linkage (CHeReL).[23]

Study population

Patients with a primary or secondary International Classification of Disease 10th revision Australian Modification (ICD-10-AM) diagnostic code for IBD (K50.x, K51.x, K52.3) who had undergone gastrointestinal surgery between 1 July 2001 and 30 September 2020 were assessed. Due to delayed data upload, data from private hospitals was only available until 30 June 2019. A total of 9078 IBD patients and 203 423 episodes of care were included.

From this cohort, patients of any age who underwent an IPAA or secondary restorative proctectomy (RPC) and IPAA based on Australian Classification of Health Intervention (ACHI) codes (Table S1) were interrogated, and only patients with primary or secondary diagnosis codes for UC (K51.x) were included. To reduce the risk of misclassification with Crohn's disease (CD) or unclassified IBD, patients with coding for both UC and CD (K50.x), or indeterminate colitis (K52.3) listed during or prior to the "pouch" episode of care were excluded. Additionally, patients who did not have coding for UC assigned at the time of pouch surgery, but were subsequently assigned in following admissions, were excluded. To capture complete financial years and allow for a minimum of 1 year follow-up from pouch surgery, the data set was limited to 30 June 2019 for public and 30 June 2018 for private hospitals in NSW (Fig. 1).

Variables

Demographic variables included age, gender, marital status, remoteness of residence (ABS statistical geographical regions[24]), socioeconomic status (index of relative socioeconomic disadvantage

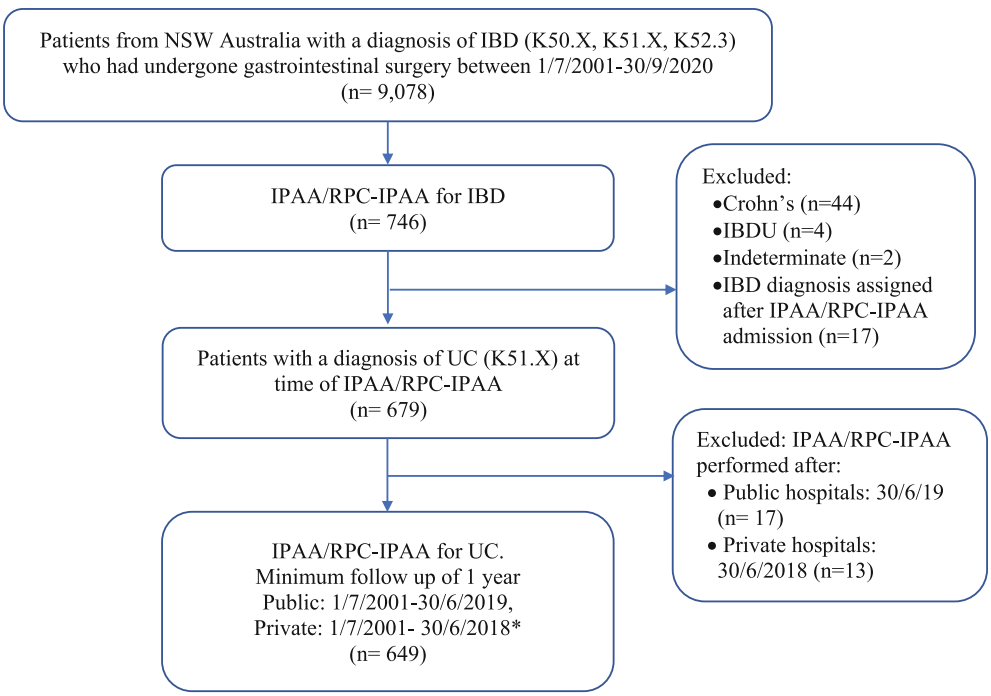

Fig. 1. Flow diagram of patients assessed for inclusion in the study. IBD, Inflammatory bowel disease; UC, ulcerative colitis; IBDU, inflammatory bowel disease unclassified; IC, indeterminate colitis; IPAA, ileo-anal pouch anastomosis; RPC, restorative proctectomy. *Private hospital data not available after 30 June 2019.

(IRSD) quintile[25]), country of birth (public hospitals only), health insurance status, and Charlson comorbidity Index (CCI) score. Acuity of operation was assigned using APDC coding; additionally patients with missing assignment were coded as 'emergency' if admission was through the emergency department. Concurrent diagnostic coding for either dysplasia (D12) or malignancy (C18-21.x, D37.3-5) were also assessed.

Hospital factors included hospital referral type, hospital peer group,[26] and hospital IBD pouch volume. Volume was stratified into terciles; low volume (LV) <1 pouch/year, medium volume (MV) 1–2 pouches/year, and high volume (HV) >6 pouches/year (Table S2), but this data was available for public hospitals only. Australia and New Zealand Training Board in Colon and Rectal Surgery (ANZTBCRS) certification was assigned if the operation was performed in a post-fellowship training public hospital.

Operative approach was classified as laparoscopic/laparoscopic assisted (Table S1) or open. Primary pouch was assigned if the IPAA and total (procto)colectomy (TPC) were performed synchronously, and secondary RPC-IPAA was assigned if reconstruction occurred after a total abdominal colectomy (TAC). The year the pouch was performed was divided into three equal time periods (2002–2007, 2008–2013, and 2014–2019). The 2014–2019 period corresponds with the introduction of infliximab for UC onto the pharmaceutical benefits scheme (PBS).[27]

Outcomes

The primary outcome was pouch failure, defined as either pouch excision, formation of a new defunctioning ileostomy, or revision of an existing ileostomy with no subsequent reversal during the follow-up period (Table S1). ACHI coding is not sensitive enough to accurately determine if a defunctioning ileostomy was formed at the time of pouch surgery. As a result, patients who had a defunctioning ileostomy formed with their pouch but never had their ileostomy reversed could not be accurately identified but is thought to be a small number.

Additional outcomes included:

(1) readmission for any reason within 30 days;
(2) postoperative surgical complication(s) (Table S1).
(3) in-hospital, 90 and 365 day mortality;
(4) intensive care unit (ICU) admission; and
(5) admission length of stay, calculated as the total length of stay for the episode of care including type change of admission and transfers.

Anonymized institution pouch volume was also graphically presented as a continuous variable plotted against pouch failure rates in a funnel plot.

Statistical analysis

Categorical variables are presented as number (percentage), and continuous variables as mean (standard deviation) or median (interquartile range) according to the distribution, and compared using the Chi-squared, Fisher's exact test, linear regression, or ANOVA.

Associations with pouch failure were assessed using Cox proportional hazards analysis. Patients were followed from the date of pouch creation to the date of pouch failure, death or 30 September 2020 (30 June 2019 for private hospitals), whichever came first. For patients who had undergone both ileostomy defunctioning and subsequent pouch excision, the first date was assigned as the failure date. Patients with primary residence outside of NSW were excluded from the analysis. Specifically, two separate Cox proportional hazards models were assessed, the first based on the total NSW population which used both public and private hospital data (Model 1), and the second based on public hospital data alone whereby a volume-outcome analysis was performed (Model 2). Both models were adjusted for age, gender, comorbidity burden, health insurance status, laparoscopic approach, malignant indication, IRSD quintile, remoteness of residence, primary or secondary pouch, and either hospital referral type (public vs. private hospital, Model 1), or hospital IBD pouch volume (Model 2).

Unadjusted secondary outcomes are presented as number of events (percent) and compared using logistic or Poisson regression.

An additional analysis was performed examining the trends in the annual volume of UC pouches performed in NSW over the 19-year time period using Poisson regression. Analysis for evidence of centralisation was performed by assessing the UC pouch volume per public hospital over three time periods categorized *a priori* based on the ACPGBI accreditation of pouch units recommendations and assessing the number of hospitals in each group.[28] Unique facility identifying codes were not available for private hospitals.

Statistical analysis was performed using R version 4.2.0.[29] All *P*-values <0.05 were considered statistically significant. Ethics approval for this study was granted by the NSW Population and Health Services Research Ethics Committee (2019/ETH13027).

Results

Study population

A total of 679 UC pouches were performed over the 19-year period. Limiting data to a minimum of 1-year follow-up left 649 for analysis (Fig. 1). The mean age at pouch surgery was 40.5 years (SD ± 15.1), and 60.7% were male. Public hospitals performed 378 pouches (58.2%), of which 255 (67.5%) were uninsured patients. Overall, a total of 364 patients (56.1%) were privately insured. Pouch surgery was more common in less disadvantaged socioeconomic groups and 73.3% of patients lived in major cities. Pouch surgery was performed on 17 patients (2.6%) with primary residences outside of NSW. Secondary pouch reconstruction was performed in 52.4% of cases and a laparoscopic or laparoscopic-assisted approach was used in 17.4% overall. Patients undergoing pouch surgery in private hospitals had no differences in comorbidities, acuity, likelihood of laparoscopic surgery, or different number of stages of pouch reconstruction surgery.

Outcomes

Pouch failure

Pouch failure occurred in 65 patients, after a median follow-up of 10.0 years. The pouch failure rate at 5 and 10 years was 8.6% (95% CI 6.3–10.8%) and 10.6% (95% CI 8.0–13.1%), respectively

(Table S3). Nearly half of all pouch failures occurred within the first 2 years (49%), and 80% within 5 years. Primary pouch excision was performed in 17, pouch diversion with no subsequent reversal in 48 patients, and an additional four went on to have pouch excision after defunctioning. Sixteen patients were salvaged after defunctioning with subsequent reversal.

Secondary outcomes

There were no in-hospital deaths, and only one death occurred within 90 days. An additional two deaths occurred within 365 days; both were unrelated to the ileal pouch operation. The overall 30-day readmission rate was 35.6% (private hospitals: 33.9%, public hospitals: 36.8%, $P = 0.511$). ICU admission was required in 9.2% of cases (private hospitals: 15.1%, public hospitals: 5.0%, $P < 0.001$). The overall complication rate was 18.3% (private hospitals: 15.1%, public hospitals 20.6%, $P = 0.092$). The median length of stay was 10 days (range 8.0–13.0) (public hospitals: 9.5 days (7.0–14.0), private hospitals: 10 days (8.0–13.0), $P = 0.534$).

Factors associated with pouch failure (Model 1)

Demographic and hospital characteristics of patients who experienced pouch failure are shown in Table 1. Adjusting for other covariates, increasing patient age was associated with pouch failure (age 40–59: aHR = 1.96 (95% CI 1.05–3.66); age ≥ 60: aHR 4.04 (95% CI 1.96–8.32)) when compared to the 18–39 year age group. Pouch formation during a non-elective admission was also significantly associated with pouch failure (aHR 4.68 (95% CI 1.74–12.55)), compared with elective admission (Table 2). Health insurance status and hospital type (public vs. private) were not significantly associated with pouch failure.

Volume-outcome analysis (Model 2)

Patient demographic and hospital characteristics for patients undergoing UC pouch surgery categorized by pouch volume tercile are shown in Table 3. The hazard of pouch failure stratified by pouch volume is shown in Figure S1. Early pouch failure (within 6 months) occurred in four (3.8%) of patients in LV, one (0.7%) in MV, and 0 (0%) in the HV centre, with the low number of events precluding statistical analysis. Pouch failure rates at 5 years were; LV: 7.8% (95% CI 2.4–12.8%), MV: 8.3% (95% CI 3.7–12.7%), HV 6.6% (95% CI 1.7–11.2%) $P_{logrank} = 0.6$.

Hospital pouch volume was not significantly associated with overall hazards of failure in the multivariable model; HV: aHR 0.64 (95% CI 0.23–1.80), MV: aHR 1.17 (95% CI 0.53–2.59) compared to LV hospitals (Table S4). The rates of pouch failure varied between NSW public hospitals as shown in the funnel plot (Fig. 2).

Median patient age at pouch surgery was positively associated with hospital pouch volume. Patients undergoing pouch surgery in the HV centre were more likely to live outside major cities, be married, be privately insured, and undergo primary (immediate) pouch reconstruction (Table 3).

Secondary outcomes categorized by pouch volume tercile for public hospitals are shown in Table 4. Although the HV centre

Table 1 Patient demographic and hospital characteristics categorized by pouch failure for all NSW hospitals (1 July 2001–30 June 2019)

Variables	No failure ($N = 567$)	Failure ($N = 65$)	*P*-value
Age, median (range)	38.0 (5–83)	46.0 (17–77)	<0.001
Age category			
≤17	26 (96.3%)	1 (3.7%)	0.002*
18–39	280 (93.0%)	21 (7.0%)	
40–59	192 (88.9%)	24 (11.1%)	
60–79	67 (77.9%)	19 (22.1%)	
≥80	2 (100.0%)	-	
Gender			
Male	348 (89.8%)	40 (10.2%)	1.00
Female	219 (89.7%)	25 (10.3%)	
Charlson comorbidity index			
0	483 (90.3%)	52 (9.7%)	<0.001
1–2	66 (85.7%)	11 (14.3%)	
≥3	18 (90.0%)	2 (10.0%)	
IRSD quintile			
1 most disadvantaged	78 (85.7%)	13 (14.3%)	0.623
2	78 (91.8%)	7 (8.2%)	
3	128 (90.1%)	14 (9.9%)	
4	130 (91.5%)	12 (8.5%)	
5 least disadvantaged	153 (89.0%)	19 (11.0%)	
Remoteness of residence			
Major city	432 (90.8%)	44 (9.2%)	0.139*
Inner regional	111 (88.1%)	15 (11.9%)	
Outer regional	20 (76.9%)	6 (23.1%)	
Remote/very remote	4 (100.0%)	-	
Health insurance			
Public (medicare)	224 (88.2%)	30 (11.8%)	0.293
Private	319 (91.1%)	31 (8.9%)	
Unclassified/missing	24 (85.7%)	4 (14.3%)	
Concurrent indication			
Malignancy	32 (86.5%)	5 (13.5%)	0.573*
Dysplasia	16 (100.0%)	-	0.394*
Time period			
2002–2007FY	211 (90.6%)	22 (9.4%)	0.169
2008–2013FY	198 (86.8%)	30 (13.2%)	
2014–2019FY†	158 (92.4%)	13 (7.6%)	
Acuity			
Elective	552 (90.5%)	58 (9.5%)	0.021*
Emergency	12 (70.6%)	5 (29.4%)	
Unclassified/missing	3 (60.0%)	2 (40.0%)	
Approach			
Laparoscopic	98 (90.7%)	10 (9.3%)	0.833
Open	469 (89.5%)	55 (10.5%)	
Hospital type			
Public	329 (90.4%)	35 (9.6%)	0.608
Private	238 (88.8%)	30 (11.2%)	
Hospital IBD pouch volume**			
HV	102 (92.7%)	8 (7.3%)	0.604
MV	132 (89.2%)	16 (10.8%)	
LV	95 (89.6%)	11 (10.4%)	
ANZTBCRS training centre**			
Yes	241 (89.6%)	28 (10.4%)	0.508
No	88 (92.6%)	7 (7.4%)	
Hospital peer group**			
Principal/tertiary	293 (89.9%)	33 (10.1%)	0.814*
Major	23 (95.8%)	1 (4.2%)	
Paediatric	13 (92.9%)	1 (7.1%)	
Reconstruction type			
Primary IPAA	270 (90.6%)	28 (9.4%)	0.573
Secondary RPC-IPAA	297 (88.9%)	37 (11.1%)	

*Fisher's exact test; **Cases performed at private hospital were excluded ($N = 238$); †30 June 2018 for private hospitals; Patients with primary residence interstate were excluded ($n = 17$). Data presented as frequency (percentage) unless indicated.

Table 2 Cox regression model for pouch failure. All patients in NSW (Public and private hospitals) between 1 July 2001 and 30 June 2019 (30 June 2018 for private hospitals)

	Univariate analysis		Multivariate analysis	
Variables	Hazard ratio (95% CI)	*P*-value	Adjusted hazard ratio (95% CI)	*P*-value
Age category				
≤17	0.59 (0.08–4.39)	0.602	0.49 (0.06–3.82)	0.492
18–39	Ref (1.00)		Ref (1.00)	
40–59	1.84 (0.99–3.41)	0.053	1.96 (1.05–3.66)	0.036
>60	3.92 (2.02–7.63)	<0.001	4.04 (1.96–8.32)	<0.001
Gender				
Male	0.96 (0.57–1.61)	0.869	0.80 (0.46–1.40)	0.437
Female	Ref (1.00)		Ref (1.00)	
Charlson comorbidity score				
0	Ref (1.00)		Ref (1.00)	
1–2	1.69 (0.85–3.34)	0.134	1.28 (0.59–2.78)	0.540
≥3	1.34 (0.33–5.52)	0.685	0.89 (0.17–4.77)	0.891
Health insurance				
Private insurance	Ref (1.00)		Ref (1.00)	
Public insurance (medicare)	1.42 (0.86–2.37)	0.175	1.89 (0.75–4.75)	0.177
Acuity				
Elective	Ref (1.00)		Ref (1.00)	
Emergency	3.95 (1.58–9.88)	0.003	4.68 (1.74–12.55)	0.002
Malignancy	1.44 (0.52–3.97)	0.483	1.04 (0.30–3.65)	0.955
IRSD Quintile				
1 (most disadvantaged)	1.43 (0.68–3.02)	0.350	1.14 (0.50–2.63)	0.753
2	0.80 (0.31–2.04)	0.634	0.58 (0.20–1.66)	0.312
3	1.03 (0.49–2.13)	0.946	1.05 (0.48–2.33)	0.896
4	0.91 (0.43–1.92)	0.799	0.90 (0.42–1.94)	0.783
5 (least disadvantaged)	Ref (1.00)		Ref (1.00)	
Remoteness of residence				
Major city	Ref (1.00)		Ref (1.00)	
Inner regional	1.29 (0.69–2.40)	0.430	1.17 (0.60–2.30)	0.648
Outer and remote	2.14 (0.84–5.41)	0.109	1.66 (0.60–2.30)	0.352
Reconstruction type				
Primary	Ref (1.00)		Ref (1.00)	
Secondary	1.09 (0.65–1.81)	0.754	1.33 (0.77–2.29)	0.304
Laparoscopic approach	0.98 (0.46–2.07)	0.956	1.00 (0.46–2.14)	0.991
Hospital type				
Private	Ref (1.00)		Ref (1.00)	
Public	1.02 (0.60–1.71)	0.954	0.59 (0.23–1.50)	0.268

Adjusted for age, gender, comorbidity burden, health insurance, concurrent malignant coding, acuity, IRSD quintile, remoteness of residence, IPAA timing, operative approach, and hospital type (public vs. private). 599 in model (33 with missing datapoints (health insurance), and 17 interstate patients excluded).

had the lowest rates of readmissions, complications and ICU admissions, none reached significance when compared to LV centres.

Pouch trends and evidence of centralization

The median number of pouches was 36.5 per year, range 24–55. The number of UC pouches performed over the study period decreased by 1.8% per year (OR 0.98, 95% CI 0.97–0.997) (Fig. 3). Use of a laparoscopic approach increased in both public and private NSW hospitals, with an average of 33.1% laparoscopic cases since the July 2014 (Table S5). Three MV and five LV hospitals had not recorded any laparoscopic/assisted pouches in the same period.

Just under one-third of all UC pouches (31.6%) were performed in a single institution, which averaged 6.5 UC pouches per year throughout the study period. Three-quarters (19/25) of NSW public hospitals who performed pouches performed less than one UC pouch annually. Five hospitals performed 1–2 pouches per year on average.

Table 5 shows the distribution of UC pouch surgery over three time periods between July 2001 and June 2020. One hospital performed around a third of all pouches in the earlier time periods although this reduced to 28% in the most recent time period. The proportion of low-volume hospitals (<1 pouch/year) increased from 58% to 70%. Six hospitals performed two-thirds of all pouches since July 2014.

Discussion

Pouch surgery is infrequently performed in NSW and the volume is reducing over time, which may be due to both reductions in the total (procto)colectomy rate, as well as a true reduction in pouch reconstruction rates. Similar reports of a reduction in the annual volume of pouch surgery have been reported in the UK,[13] although other international data conflicts this.[5,14,15,30] Nevertheless, pouch outcomes in NSW with respect to pouch failure and complications rates are comparable to published literature, though factors associated with these outcomes warrant further discussion, particularly in

Table 3 Patient demographics and hospital characteristics categorized by hospital pouch volume for ulcerative colitis patients undergoing pouch surgery in NSW public hospitals between 1 July 2001 and 30 June 2019

Variables	Hospital pouch volume			*P*-value
	Low volume *N* = 107 (28.3%)	Medium volume *N* = 148 (39.2%)	High volume *N* = 123 (32.5%)	
Age, median (range)	33.0 (5–83)	36.5 (14–70)	42.0 (16–77)	0.002
Age category				
≤17	16 (15.0%)	6 (4.1%)	1 (0.8%)	<0.001†
18–39	51 (47.7%)	78 (52.7%)	50 (40.7%)	
40–59	25 (23.4%)	46 (31.1%)	54 (43.9%)	
60–79	14 (13.1%)	18 (12.2%)	18 (14.6%)	
≥80	1 (0.9%)	-	-	
Gender				
Male	65 (60.7%)	91 (61.5%)	67 (54.5%)	0.459*
Female	42 (39.3%)	57 (38.5%)	56 (45.5%)	
Charlson comorbidity index				
0	91 (85.0%)	128 (86.5%)	99 (80.5%)	0.228
1–2	15 (14.0%)	14 (9.5%)	17 (13.8%)	
≥3	1 (0.9%)	6 (4.1%)	7 (5.7%)	
IRSD quintile				
1 most disadvantaged	23 (21.5%)	32 (21.6%)	15 (12.2%)	0.253
2	21 (19.6%)	18 (12.2%)	20 (16.3%)	
3	16 (15.0%)	37 (25.0%)	26 (21.1%)	
4	22 (20.6%)	33 (22.3%)	30 (24.4%)	
5 least disadvantaged	24 (22.4%)	28 (18.9%)	19 (15.4%)	
Unclassified	1 (0.9%)	-	13 (10.6%)	
Remoteness of residence				
Major city	85 (79.4%)	118 (79.7%)	61 (49.6%)	<0.001
Inner regional	17 (15.9%)	27 (18.2%)	36 (29.3%)	
Outer regional	4 (3.7%)	3 (2.0%)	9 (7.3%)	
Remote/very remote	-	-	4 (3.3%)	
Interstate	1 (0.9%)	-	13 (10.6%)	
Health insurance				
Public (medicare)	80 (74.8%)	113 (76.4%)	62 (50.4%)	<0.001
Private	20 (18.7%)	29 (19.6%)	61 (49.6%)	
Unclassified/missing	7 (6.5%)	6 (4.1%)	-	
Country of birth				
Australia	67 (62.6%)	117 (79.1%)	97 (78.9%)	0.008
Other	38 (35.5%)	31 (20.9%)	25 (20.3%)	
Unclassified/missing	2 (1.9%)	-	1 (0.8%)	
Concurrent indication				
Malignancy	5 (4.7%)	5 (3.4%)	11 (8.9%)	0.123
Dysplasia	3 (2.8%)	1 (0.7%)	3 (2.4%)	0.387
Time period				
2002–2007FY	45 (42.1%)	49 (33.1%)	41 (33.3%)	0.401
2008–2013FY	36 (33.6%)	51 (34.5%)	49 (39.8%)	
2014–2019FY	26 (24.3%)	48 (32.4%)	33 (26.8%)	
Acuity				
Elective	101 (94.4%)	141 (95.3%)	119 (96.7%)	0.314
Emergency	6 (5.6%)	6 (4.1%)	2 (1.6%)	
Unclassified/missing	-	1 (0.7%)	2 (1.6%)	
Approach				
Laparoscopic	21 (19.6%)	22 (14.9%)	24 (19.5%)	0.505
Open	86 (80.4%)	126 (85.1%)	99 (80.5%)	
ANZTBCRS training centre				
Yes	43 (40.2%)	117 (79.1%)	123 (100%)	<0.001
No	64 (59.8%)	31 (20.9%)	-	
Hospital peer group			-	
Principal/tertiary	69 (64.5%)	148 (100%)	123 (100%)	<0.001
Major	24 (22.4%)	-	-	
Paediatric	14 (13.1%)	-	-	
District or subacute	-	-	-	
Other	-	-	-	
Reconstruction type				
Primary IPAA	38 (35.5%)	64 (43.2%)	68 (55.3%)	0.009
Secondary IPAA	69 (64.5%)	84 (56.8%)	55 (44.7%)	

*Fisher's exact test. † ≥ 80 collapsed for chi-squared.

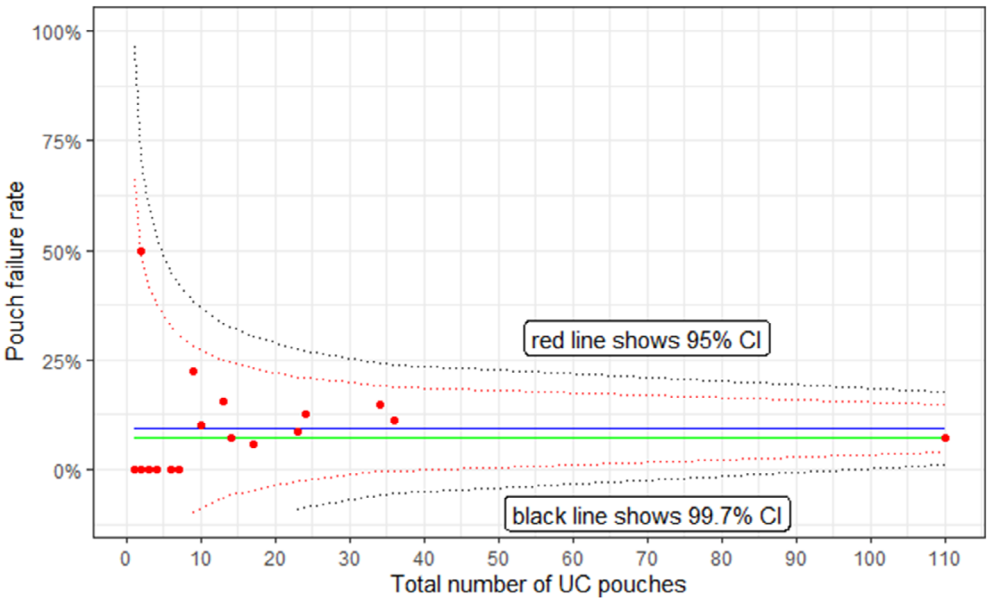

Fig. 2. Funnel plot of anonymized NSW public hospital overall pouch failure rate plotted against the total volume of UC pouches performed between 1 July 2001 and 30 June 2019. Mean overall failure rate was 9.3% (Blue), median 7.3% (Green).

light of contemporary guidelines which recommend a minimum caseload for unit accreditation.

Overall 76% of NSW public hospitals were in the low volume group (<1 UC pouch/year), which is consistent with the global experience,[5–7,13–15] and there is no evidence to suggest a trend towards centralisation. Evidence of established pathways for centralisation exist with one hospital performing nearly a third of all UC pouches over the period. Since July 2008, five to six main hospitals have performed two-thirds of all pouches although there has been some movement of hospitals between annual volume categories. International recognition of the high proportion of LV pouch hospitals, along with the development of IBD quality of care guidelines, has led to recommendations for greater scrutiny of patient outcomes overseas.[10,31,32] This has led to a debate about the delivery of pouch surgery at a national structural level in countries including the UK, with suggestions that centralizing IBD pouch surgery to fewer trusts, thereby facilitating greater institutional volume may result in improved patient outcomes.[4,16,33] Numerous studies have identified a clear volume outcome relationship for multiple pouch related outcomes.[5–7,14,15,22,30,34–38]

It would seem though, that the volume-outcome relationship for pouch surgery is complex. In our study, hospital volume was not significantly associated with failure despite slightly higher failure rates outside the HV centre (5 year failure; HV: 6.6% vs. MV: 8.3% and LV: 7.8%). This may be due to issues with small study population and even smaller numbers of events observed (e.g., 35 pouch failures in NSW public hospitals) despite a nearly 20 year period of analysis. Additionally, categorization of pouch volume into terciles has its weakness, particularly given there was movement of hospitals between the volume categories during the study period. It is also conceivable that the null relationship between volume and outcome is true, as some LV centres are achieving excellent results while not all medium to high volume centres are able to achieve the same high quality results.[22] Early pouch failure (≤ 6 months) was higher in LV centres possibly suggesting a lower rate of early pouch salvage, which is consistent with the global experience.[22] Transfer of patient care to HV centres to undergo pouch salvage appears limited.

The overall pouch failure rate at 5 and 10 years in NSW (8.6% and 10.6%, respectively) is comparable to those published in a recent systematic review which estimated the pooled pouch failure rate at 7.7% and 10.3%[9] with a median follow up of ≥5 and ≥ 10 years respectively. Reported 5 year pouch failure rates in international high volume specialist centres include 3.7% at the

Table 4 Secondary outcomes following ulcerative colitis pouch surgery in NSW public hospitals (1 July 2001–30 June 2019) categorized by IBD pouch volume

	Frequency (%)			Odds ratio (95% CI)		
	Low volume $N = 107$ (28.3%)	Medium volume $N = 148$ (39.2%)	High volume $N = 123$ (32.5%)	Low volume	Medium volume	High volume
30-day readmission†	35 (32.7%)	66 (44.6%)	38 (30.9%)	Ref (1.00)	1.63 (0.98–2.76)	0.91 (0.52–1.59)
ICU admissions	7 (6.5%)	9 (6.1%)	3 (2.4%)	Ref (1.00)	0.93 (0.33–2.67)	0.36 (0.08–1.32)
Perioperative surgical complications	21 (19.6%)	37 (25.0%)	20 (16.3%)	Ref (1.00)	1.37 (0.75–2.53)	0.80 (0.40–1.57)
Length of stay‡	9 (6.0–12.5)	10 (8.0–14.0)	10 (8.0–13.0)	Ref (1.00)	1.16 (1.08–1.24)	1.01 (0.94–1.09)

†Excluding patients who died in hospital. ‡Median (IQR). HV, high volume; LV, low volume; MV, medium volume.

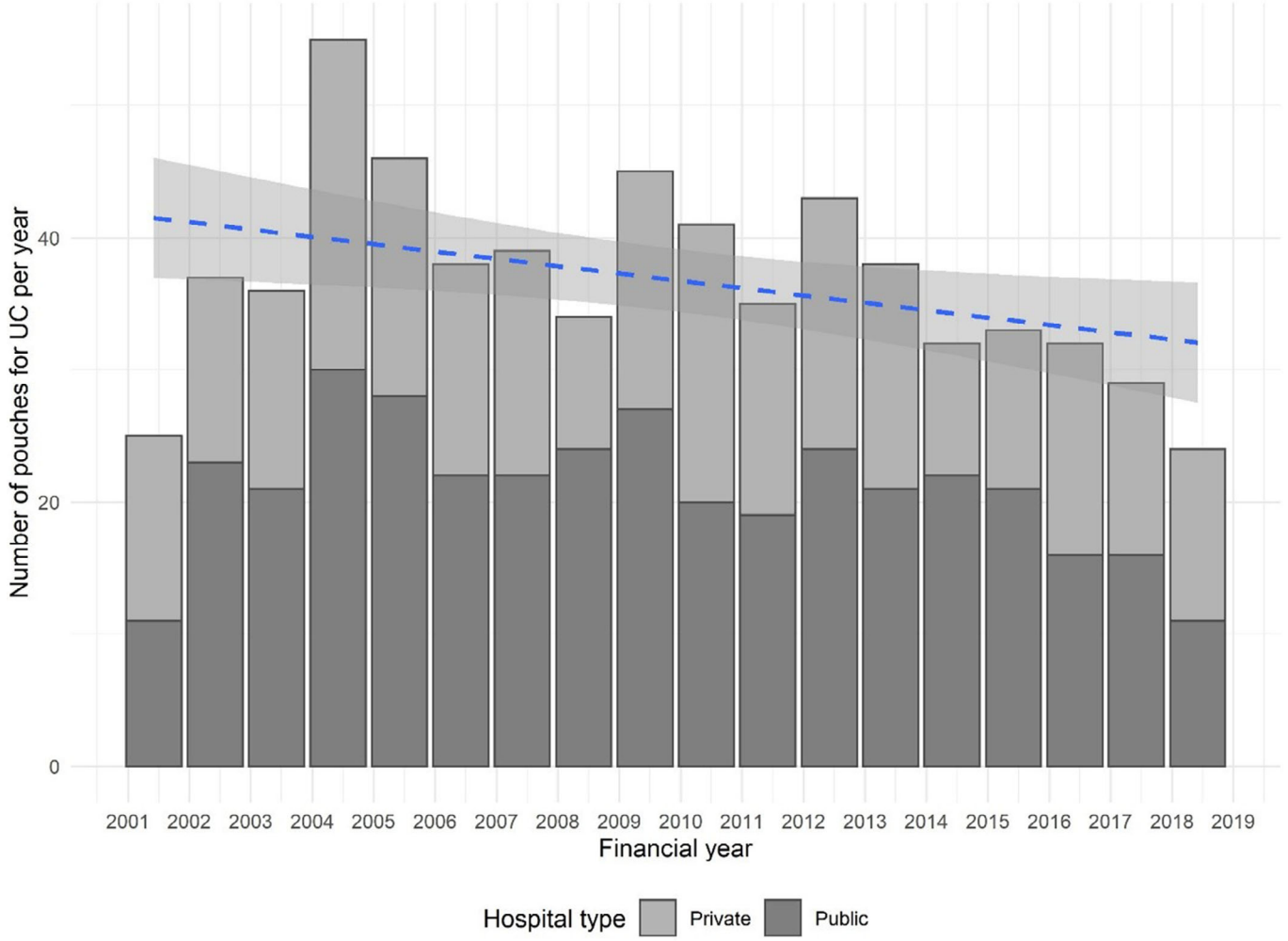

Fig. 3. Stacked bar graph and smooth line with 95% confidence interval representing the annual volume of pouches for ulcerative colitis in NSW public and private hospitals between 1 July 2001 and 30 June 2019.

Mayo clinic, 4.1–4.6% at the Cleveland clinic, and 9% at St Marks.[3,39–41] The rate of failure in the UK using administrative data was 6.4% with a medium follow up of 65 months, although the study was not limited to a UC cohort.[22] However, the pouch failure rate is lower than that reported in both Denmark (9.1% at 5 years and 12.1% at 10 years), and Sweden (12.8% at 5 years) in UC cohorts at a population level.

Table 5 Hospital ulcerative colitis pouch volume categories over time

Pouch volume category	Pouches/ year	No. pouches	No. of hospitals
Period 1 (July 2001–June 2007)		*N* = 135	*N* = 19
Low volume	>0 to <1	33 (24.4%)	11 (57.9%)
Medium volume	1–4	61 (45.2%)	7 (36.8%)
High volume	≥5	41 (30.4%)	1 (5.3%)
Period 2 (July 2007–June 2013)		*N* = 136	*N* = 21
Low volume	>0 to <1	30 (22.1%)	14 (66.7%)
Medium volume	1–4	57 (41.9%)	6 (28.6%)
High volume	≥5	49 (36.0%)	1 (4.8%)
Period 3 (July 2013–June 2020)		*N* = 122	*N* = 20
Low volume	>0 to <1	38 (31.1%)	14 (70.0%)
Medium volume	1–4	50 (41.0%)	5 (25.0%)
High volume	≥5	34 (27.9%)	1 (5.0%)

Data presented as frequency (%). NSW public hospitals who performed pouches in each time period 1 July 2001–30 June 2020.

Mortality rates after pouch surgery were low with only one death (0.2%) within 90 days and two additional deaths within 365 days of pouch surgery. These findings are reassuring given the mostly elective nature of the procedure and compare favourably with international reports.[6,22] The overall 30-day readmission rate of 35.6% is higher than reports from the UK (27.4%), Canada (10.5%), and the USA (19.5–22.8%),[4,5,7,14] but variation existed between NSW hospitals. Readmission rates are a surrogate measure of quality of care and the high rates in NSW warrant further investigation. Structural factors and processes of care, including limited outpatient access to specialist IBD nurses and stomal therapists, as well as the high rate of defunctioning ileostomy formation in NSW, may be contributory factors.[18]

The use of a laparoscopic or laparoscopic-assisted approach in NSW (33.1% since 2014FY) is comparable to reports form the UK (34.2%), and remains higher than the rates reported in a recent

systematic review (24%).[4,9] However, we were not able to report conversion rates or when a partial laparoscopic procedure was performed. Laparoscopic assisted pouch surgery, which includes either a pfannensteil or lower midline incision to mature the pouch extracorporeally, has been shown to be both feasible and safe in appropriate patients and may improve fertility rates for female patients,[12,42] therefore justifying it as a potential marker of 'good quality' pouch surgery.

The management of IBD patients undergoing pouch surgery is complex and relies on high-quality multimodal care beyond the surgeon including experienced IBD physicians, nurses, stomal therapists, radiologists, and pathologists. Development of knowledge and experience for all members of the multidisciplinary IBD team is reliant on sufficient exposure and resource allocation. Intuitively, consolidation of IBD pouch surgery to fewer centres with established infrastructure and specialist IBD physicians, many of whom are already contributing to collaborative data sets, should result in improved long-term audit in NSW. While there is a population need for multiple specialist IBD medical clinics it may be that collaboration between these medical clinics and a smaller number of higher volume surgical IBD centres is the way of the future.

This study was limited by the inability to track individual or teams of surgeons who work across more than one NSW public and private hospital, equivalent to the 'trust' level in the UK.[22] Given that 42% of UC pouches were performed in NSW private hospitals it is therefore likely that the annual volume for teams of surgeons is underestimated, and that some cases performed in LV hospitals may have been performed by higher volume surgeons. However, this does not understate the importance of the 'surgical IBD centre' with experienced IBD teams rather than a surgeon in isolation as the most important variable. This study was strengthened by its comprehensive coverage of the NSW population over the time period, providing a 'real world' experience. The ability to follow patients longitudinally across NSW ensures accurate capture of readmissions and pouch failure.

Conclusions

The outcomes following pouch surgery for UC in NSW are comparable with global standards. Only one centre performed >5 pouches annually and while not significant, demonstrated lower rates of pouch failure, 30-day readmission, and complications. IBD Pouch surgery is complex and the management of the post-operative complications can be challenging. Our finding that three-quarters of NSW hospitals performed very low volumes (<1 UC pouch/year), especially interpreted in light of ACPGBI guidelines, strongly suggests that these patients should be centralized to a limited number of units capable of performing at least 5 pouches annually. Concentrating IBD pouch surgery, with the aim of producing specialist IBD pouch surgical teams would seem like a reasonable way forward in NSW and would ensure equity of access to specialist surgical services as well as help research and training collaboration.

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Author contributions

Hugh L. Giddings: Conceptualization; data curation; formal analysis; methodology; project administration; visualization; writing – original draft. **Kheng-Seong Ng:** Conceptualization; data curation; formal analysis; methodology; project administration; supervision; writing – original draft. **Michael Solomon:** Conceptualization; methodology; project administration; supervision; writing – original draft; writing – review and editing. **Daniel Steffens:** Data curation; project administration; supervision; writing – review and editing. **Joe Van Buskirk:** Formal analysis; methodology; visualization. **Jane Young:** Conceptualization; data curation; methodology; project administration; supervision; writing – review and editing.

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Conflicts of interest

None declared.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Figure S1. Kaplan–Meier plot showing the hazards of pouch failure stratified by hospital pouch volume for NSW public hospitals performed between 1/7/2001–2030/6/2019. HV: High volume, MV: Medium volume, LV: Low volume.

Table S1. International Classification of Diseases 10th revision Australian modification (ICD-10-AM), Australian Classification of Health Intervention (ACHI) codes.

Table S2. Hospital pouch volume categories (terciles) for any IBD indication.

Table S3. Cumulative incidence of pouch failure for ulcerative colitis.

Table S4. Cox regression model for pouch failure (NSW public hospitals).

Table S5. Percentage of pouches performed laparoscopically, or laparoscopic assisted by hospital type and hospital pouch volume tercile.