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Variations in practice of thromboprophylaxis across general surgical subspecialties: a multi-centre (PROTECTinG) study of elective major surgeries

Running title: Thromboprophylaxis in general surgery

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Abstract

Background

Despite guidelines recommending perioperative thromboprophylaxis for patients undergoing general surgery, we have observed significant variations in its practice. This may compromise patient safety. Here, we quantify the heterogeneity of perioperative thromboprophylaxis across all major general surgical operations, and place them in relation to their risk of bleeding and venous thromboembolism.

Methods

Retrospective review of all elective major general surgeries performed between 1 January 2018 to 30 June 2019, across seven Victorian hospitals.

Results

5912 patients who underwent 6628 procedures were reviewed. Significant heterogeneity was found in the use of chemoprophylaxis, timing of its initiation, type of anticoagulant administered, and application of extended chemoprophylaxis. These variations were observed within the same procedure, and between different surgeries and subspecialties. Contrastingly, there was minimal heterogeneity with the use of mechanical thromboprophylaxis. Oesophago-gastric, liver and colorectal cancer resections had the highest thromboembolic risk. Breast, oesophago-gastric, liver, pancreas and colon cancer resections had the highest bleeding risk.

Conclusions

Perioperative chemoprophylaxis across general surgery is highly variable. This study has highlighted key areas of variance. Our findings also enable surgeons to compare their practices, and provide baseline data to inform future efforts towards optimising thromboprophylaxis for general surgical patients.

Introduction

General surgical patients who undergo major operations are at risk of venous thromboembolism (VTE). This incurs significant morbidity and healthcare costs.(1) Therefore, the Royal Australasian College of Surgeons and other regulatory bodies recommend routine thromboprophylaxis.(1, 2) Moreover, considerations for thromboprophylaxis is an integral part of theatre timeout performed prior to any operation.

Despite the common practice of thromboprophylaxis, and the existence of guidelines supporting its use,(2) we have observed significant variations in practice amongst general surgeons. As evidence, a multi-centre survey of trainees and surgeons, performed by the PROTECTinG (Perioperative Timing of Elective Chemical Thromboprophylaxis in General surgery) investigators through the VERITAS collaborative, have demonstrated that the use and timing of chemoprophylaxis were highly variable. (3) Additionally, it was found that guidelines were often vague or out-of-date, and thus frequently abandoned. Consequently, many clinicians based their decision-making on surgical dogma and personal experiences. Unfortunately, such an approach can lead to inadequate protection against VTE or increase post-operative bleeding risk.(4)

In this study, we extend the observations made from our multi-centre survey by quantifying the heterogeneity of perioperative thromboprophylaxis across all major general surgical operations, and placing them in context of their bleeding and VTE risk. Findings from this study will highlight areas of practice with the greatest variability, allow surgeons to benchmark their practices against that of their colleagues, and focus future research to optimise perioperative thromboprophylaxis.

Methods

Study design

Consecutive patients who underwent major general surgical procedures from 1 January 2018 to 30 June 2019 at seven Victorian hospitals (Austin, Heidelberg Repatriation, The Northern, Broadmeadows, Box Hill, Maroondah, and Angliss hospitals) in Australia were retrospectively analysed. Surgeries were performed by 105 consultant surgeons, 39 surgical fellows and 85 trainees. Patients were identified from administrative databases using the Australian Classification of Heath Interventions procedural codes (**Table S1**). Patients <18 years-of-age, emergency surgeries and surgeries <45 minutes (minor operations) were excluded. This study received multi-centre ethics approval (35678).

Thromboprophylaxis

Thromboprophylaxis was at the surgeon's discretion. Mechanical thromboprophylaxis included sequential compression devices and graduated compression stockings used alone or in combination. Chemoprophylaxis included subcutaneous enoxaparin (daily), dalteparin (daily) or heparin (twice daily), at doses adjusted to each patient's weight and renal function. Chemoprophylaxis was initiated either pre-operatively (before knife-to-skin), post-operatively (after skin closure) or intra-operatively. Extended chemoprophylaxis was defined by its continued usage for ≥14-days post-discharge.

Clinical VTE and bleeding

Clinical VTE was defined as imaging-proven (CTPA, V/Q scan or venous duplex ultrasound) symptomatic disease within 30-days of surgery. Post-operative bleeding was defined as haemorrhage which occurred within the same admission period post-surgery. Major bleeding was defined as the need for re-operation, blood transfusion, or >20 g/L fall in haemoglobin from baseline.(4) These events were identified from administrative databases using the International Classification for Diseases v.10 (**Table S2**).

Data collection and analysis

Data was captured from patient records onto a universal electronic proforma. Standardized training sessions were conducted prior to data collection to minimise inter-observer disagreements. Descriptive statistics were derived using Prism v8 (GraphPad, San Diego, USA).

Results

We reviewed 5912 patients who underwent 6628 major operations, and categorised them into surgical subspecialties.

Variability across oesophago-gastric surgery

Overall, 685 operations were performed (**Table 1**). We found minimal variability with the use of mechanical (98.6-100.0%) and chemical (88.7-100.0%) thromboprophylaxis. Altogether, 7.8% of patients received extended chemoprophylaxis. This was more common following weight-loss procedures (9.1-9.8%) and cancer resections (16.7%). The areas of greatest variability lie in the type of chemoprophylaxis administered (Enoxaparin: 36.2-66.2%, dalteparin: 28.7-43.8%, and heparin: 5.1-21.3%) and their time of initiation (Pre-op: 0.0-3.3%, intra-op: 34.4-61.9%, and post-op: 37.5-63.3%).

Variability across breast surgery

Overall, 1572 procedures were undertaken (**Table 2**). Besides the consistently low use of extended chemoprophylaxis (0.0-2.0%), we found substantial variability with the use of mechanical (64.0-100.0%) and chemical (8.0-75.8%) thromboprophylaxis. Chemoprophylaxis was most commonly administered to patients who underwent mastectomies, and not prescribed to those who undergone axillary nodal biopsies. In patients who received chemoprophylaxis, inconsistencies were identified in the type of chemoprophylaxis administered (Enoxaparin: 24.0-68.6%, dalteparin: 0.0-28.1%, and heparin: 18.2-54.0%) and their time of initiation (Pre-op: 0.0-2.0%, intra-op: 35.1-64.7%, and post-op: 33.3-63.6%).

Variability across colorectal surgery

Overall, 843 surgeries were conducted (**Table 3**). Aside from patients who underwent a Delorme's mucosectomy for rectal prolapse, we found consistently high utilisation of mechanical (94.4-100.0%) and chemical (86.9-100.0%) thromboprophylaxis for all other colorectal procedures. Extended chemoprophylaxis was prescribed in 19.8% of patients, a practice predominately seen after rectal (24.9%) and colon (19.8%) cancer resections. We identified high variability in the type of chemoprophylaxis administered (Enoxaparin: 50.5-75.0%, dalteparin: 21.4-42.9%, and heparin: 0.0-11.3%) and their time of initiation (Pre-op: 0.0-3.8%, intra-op: 11.8-33.8%, and post-op: 64.3-88.2%).

Variability across endocrine surgery

Overall, 805 operations were performed (**Table 4**). These were associated with a high rate of mechanical thromboprophylaxis (97.5%) and a low rate of extended chemoprophylaxis (2.9%). In contrast to other subspecialties, endocrine surgery had the lowest overall rate of chemoprophylaxis utilisation (17.3%). This was mainly restricted to the post-operative period (92.8%). Chemoprophylaxis varied significantly between surgeries, with 82.1% of adrenalectomy patients receiving chemoprophylaxis compared to only 12.7% of thyroidectomy and 17.4% of parathyroidectomy patients. Furthermore, there were variations in the type of chemoprophylaxis administered (Enoxaparin: 0.0-87.5%, dalteparin: 12.5-50.0%, and heparin: 0.0-50.0%).

Variability across hepatobiliary-pancreas surgery

Overall, 2073 procedures were undertaken (**Table 5**) with cholecystectomies accounting for the majority (86.4%) of these cases. Aside from cholecystectomies, there was minimal variability with the use of mechanical (100.0%) and chemical (92.1-100.0%) thromboprophylaxis. Altogether, 6.0% of patients received extended chemoprophylaxis. This practice largely followed liver (41.9%) and pancreatic (26.8-42.9%) cancer resections. The areas of greatest variability were found in the type of chemoprophylaxis administered (Enoxaparin: 40.8-65.4%, dalteparin: 14.3-36.6%, and heparin: 6.2-22.9%) and their time of initiation (Pre-op: 0.0-24.7%, intra-op: 34.3-42.3%, and post-op: 43.1-62.9%).

Variability across non-specialist general surgery

Overall, 650 surgeries were conducted (**Table 6**) with the majority being ventral hernia repairs (83.2%). We found substantial heterogeneity across all domains of thromboprophylaxis. This included its use (mechanical: 64.9-100.0%, chemical: 0.0-91.4%), type (Enoxaparin: 60.0-80.0%, dalteparin: 18.8-36.7%, and heparin: 0.0-7.4%) and timing of chemoprophylaxis administration (Pre-op: 0.0-15.6%, intra-op: 25.0-60.0%, and post-op: 40.0-66.7%). Similar to other subspecialties, the use of extended chemoprophylaxis was low (2.6%) in this group, and it was mainly observed in patients with underlying malignancies (lymph node biopsies: 40.0%, staging laparotomies: 18.8%).

Clinical VTE and bleeding rates across subspecialties

Of the 5912 patients, symptomatic VTE and bleeding were identified in 25 [0.4%, PE: 15 (0.3%), DVT: 17 (0.3%), both: 7 (0.1%)] and 209 (3.5%) cases respectively. 73.2% (153 patients) of post-operative bleeding were major events, which required surgical control in 73 (32.5%) cases. Bleeding rates were not significantly different between fractionated (5.0%) and unfractionated heparin (6.5%). Forty (0.7%) patients died within 30-days post-surgery. Of these, VTE and bleeding contributed to two and five cases respectively. Among the subspecialties (**Table 7**), colorectal surgery carried the highest risk of clinical VTE (1.3%) and bleeding (5.2%), whilst endocrine surgery had the lowest risk of both complications (VTE: 0.0%, bleeding: 1.4%). Among the operations, cancer resections of the oesophagus/stomach, liver, colon and rectum were associated with the highest risk of clinical VTE (top quartile: ≥1.0% risk), while cancer resections of the oesophagus/stomach, liver, pancreas and colon as well as mastectomies were associated with the highest risk of bleeding (top quartile: ≥6.8% risk). Conversely, fundoplication/hiatus hernia repairs, excisional breast biopsies, thyroidectomies and parathyroidectomies carried the lowest risk of bleeding (bottom quartile: ≤1.9% risk).

Discussion

This is the first study to comprehensively examine the heterogeneity of thromboprophylaxis across general surgical subspecialties. We have highlighted four areas with substantial variations in practice, these include: 1) use of chemoprophylaxis, 2) timing of its initiation, 3) type of anticoagulant administered and 4) application of extended chemoprophylaxis. Variations in these domains were seen per procedural type, across different surgeries, and between subspecialties.

Variable use of chemoprophylaxis was most commonly seen in surgeries on the neck, breast, gall bladder, and ventral hernias. This may be explained by their inherently low but not absent VTE risk, their relatively higher though not exceedingly high rate of post-operative bleeding,(4-7) discrepant literature which encourages yet questions the need for chemoprophylaxis,(8) confusing guidelines which broadly recommends chemoprophylaxis without accounting for individual risks,(2) and a fear of litigation which may influence decision-making.(9) Importantly, chemoprophylaxis use has been associated with increased bleeding in these operations.(4, 6, 7) Notably, bleeding risk post thyroid/parathyroid surgeries significantly outweighs that of VTE in most patients. (6) Taken together, these findings highlight the need to refine guidelines for these commonly performed operations.

Besides colorectal and neck surgeries, all other subspecialties varied significantly in their time of starting chemoprophylaxis. Following colorectal and neck surgeries, chemoprophylaxis was typically administered post-operatively. This practice is likely driven by the need to avoid bleeding, which is more common post colorectal resections and imminently life-threatening in the neck. However, post-operative chemoprophylaxis is incongruent with guidelines from the American Society of Clinical Oncology and European Society of Medical Oncology, which recommend chemoprophylaxis prior to cancer (excluding breast and thyroid) resections.(10) The heterogeneity in timing among non-endocrine/colorectal surgeries, particularly for benign conditions, may reflect poor evidence, a lack of consensus guidelines, and practice based on dogma, institutional factors and heuristics.(3) Importantly, inappropriately timed chemoprophylaxis may contribute to increased bleeding and mortality.(4, 11) These findings

emphasize the need to further examine how timing of chemoprophylaxis impacts surgical outcomes, particularly for operations on the gastrointestinal system, where bleeding and VTE risks are high.

We found inconsistencies in the type of chemoprophylaxis administered across all operations. Overall, low molecular weight heparin (LMWH: enoxaparin and dalteparin) was used more frequently than unfractionated heparin (UFH). This is likely because LMWH is easier to use due to a longer half-life when compared to UFH.(12) Additionally, LMWH may provide greater thromboembolic protection with less risk of heparin-induced thrombocytopenia than UFH.(13, 14) However, these benefits are offset by the limited reversibility of LMWH, despite both having comparable bleeding profiles.(15) Currently, enoxaparin and dalteparin are assumed to be equivalent in their efficacy and risk, (15) thus accounting for the dichotomy in their usage within our patient cohort.

In this study, extended chemoprophylaxis was mainly restricted to patients undergoing weight-loss surgery and gastrointestinal cancer resections. However, <50% of cancer patients and <10% of bariatric patients were prescribed extended chemoprophylaxis. This is despite recent meta-analyses demonstrating its safety and efficacy after abdominopelvic surgery for malignant and benign diseases.(16, 17) Furthermore, there is mounting evidence supporting its use after bariatric, liver and pancreas surgeries.(18, 19) Therefore, it is imperative that consensus guidelines are continually revised to reflect the latest research developments.

Our study has several limitations. First, this is an audit of seven Victorian hospitals, our findings may not extend beyond these services. Second, we did not determine the reasons underlying variability in practice, this has been addressed elsewhere.(3) Third, we did not examine other areas where variability in thromboprophylaxis may exist (e.g. dosing and use of mixed regimens). Fourth, the true incidence of VTE including symptomatic cases could not be defined by this study, as patients may not represent to hospital or to the same healthcare network.

Overall, perioperative chemoprophylaxis across general surgery is inconsistent. Variations in practice between subspecialties can be rationalised based on different VTE and bleeding risks inherent to the surgeries performed

within each subspecialty. Variability within the same operation may be explained by individual patient risks for VTE or bleeding. However, we are doubtful that this would adequately explain the significant practice variability observed for the same procedure in this study. We propose that rationalisable variability is a necessary part of clinical care and should be documented. However, unrationalisable variability may be harmful. This study highlights areas of variance, allows comparison of practice, and provides baseline data to inform efforts towards standardising thromboprophylaxis for general surgical patients.

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Table 1. Oesophago-gastric surgery

		Thromboprophylaxis usage		Chemoprophylaxis timing			Extended	Type		
Operations	**N**	**Mechanical**	**Chemical**	**Pre-op**	**Intra-op**	**Post-op**	**Chemical**	**Enoxaparin**	**Heparin**	**Dalteparin**
Gastric sleeve	310	306 (98.7%)	307 (99.0%)	2 (0.7%)	190 (61.9%)	115 (37.5%)	28 (9.1%)	194 (63.2%)	23 (7.5%)	90 (29.3%)
Gastric bypass	115	114 (99.1%)	112 (97.4%)	0 (0.0%)	61 (54.5%)	51 (45.5%)	11 (9.8%)	56 (50.0%)	7 (6.3%)	49 (43.8%)
Fundoplication/Hiatus hernia repair	146	144 (98.6%)	136 (93.2%)	1 (0.7%)	74 (54.4%)	61 (44.9%)	3 (2.2%)	90 (66.2%)	7 (5.1%)	39 (28.7%)
Oesophago-gastric resection	61	61 (100.0%)	61 (100.0%)	2 (3.3%)	21 (34.4%)	38 (63.3%)	10 (16.7%)	32 (52.5%)	10 (16.7%)	19 (31.7%)
Others (See Table S3)	53	53 (100.0%)	47 (88.7%)	1 (2.1%)	22 (46.8%)	24 (51.1%)	0 (0.0%)	17 (36.2%)	10 (21.3%)	20 (42.6%)
Overall	**685**	**678 (99.0%)**	**663 (96.8%)**	**6 (0.9%)**	**368 (55.5%)**	**289 (43.6%)**	**52 (7.8%)**	**388 (58.7%)**	**57 (8.6%)**	**217 (32.7%)**

Table 2. Breast surgery

		Thromboprophylaxis usage		Chemoprophylaxis timing			Extended	Type		
Operations	**N**	**Mechanical**	**Chemical**	**Pre-op**	**Intra-op**	**Post-op**	**Chemical**	**Enoxaparin**	**Heparin**	**Dalteparin**
Mastectomy, simple/subcutaneous										
Without reconstruction	256	250 (97.7%)	158 (61.7%)	1 (0.6%)	62 (39.2%)	95 (60.1%)	2 (1.3%)	62 (39.2%)	52 (32.9%)	44 (27.8%)
With reconstruction	66	66 (100.0%)	50 (75.8%)	1 (2.0%)	25 (50.0%)	24 (48.0%)	1 (2.0%)	12 (24.0%)	27 (54.0%)	11 (22.0%)
Wide local excision, breast	451	434 (96.2%)	129 (28.6%)	2 (1.6%)	77 (59.7%)	50 (38.8%)	1 (0.8%)	75 (58.1%)	36 (27.9%)	18 (14.0%)
Excisional biopsy	158	144 (91.1%)	51 (32.3%)	1 (2.0%)	33 (64.7%)	17 (33.3%)	0 (0.0%)	35 (68.6%)	16 (31.4%)	0 (0.0%)
Lymph node clearance, axilla	145	143 (98.6%)	77 (53.1%)	1 (1.3%)	27 (35.1%)	49 (63.6%)	1 (1.3%)	44 (57.1%)	14 (18.2%)	19 (24.7%)
Lymph node biopsy, axilla, sentinel	471	453 (96.2%)	153 (32.5%)	2 (1.3%)	72 (47.1%)	79 (51.6%)	1 (0.7%)	57 (37.3%)	53 (34.6%)	43 (28.1%)
Others (See Table S3)	25	16 (64.0%)	2 (8.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	0 (0.0%)
Overall	**1572**	**1506 (95.8%)**	**620 (39.4%)**	**8 (1.3%)**	**297 (47.9%)**	**315 (50.8%)**	**6 (1.0%)**	**286 (46.1%)**	**199 (32.1%)**	**135 (21.8%)**

Table 3. Colorectal surgery

		Thromboprophylaxis usage		Chemoprophylaxis timing			Extended	Type		
Operations	**N**	**Mechanical**	**Chemical**	**Pre-op**	**Intra-op**	**Post-op**	**Chemical**	**Enoxaparin**	**Heparin**	**Dalteparin**
Rectal resection	305	305 (100.0%)	301 (98.7%)	4 (1.3%)	57 (18.9%)	240 (79.7%)	75 (24.9%)	152 (50.5%)	20 (6.6%)	129 (42.9%)
Colon resection	255	255 (100.0%)	254 (99.6%)	5 (2.0%)	44 (17.4%)	205 (80.6%)	53 (19.8%)	135 (53.4%)	17 (6.5%)	101 (40.1%)
Stoma creation, ileostomy	92	92 (100.0%)	90 (97.8%)	2 (2.2%)	17 (18.9%)	71 (78.9%)	29 (32.2%)	49 (54.4%)	6 (6.7%)	35 (38.9%)
Stoma creation, colostomy	18	17 (94.4%)	17 (94.4%)	0 (0.0%)	2 (11.8%)	15 (88.2%)	3 (17.6%)	11 (64.7%)	0 (0.0%)	6 (35.3%)
Stoma closure, ileostomy	83	81 (97.6%)	80 (96.4%)	1 (1.3%)	27 (33.8%)	52 (65.0%)	3 (3.8%)	44 (55.0%)	6 (7.5%)	30 (37.5%)
Hartmann's reversal	29	29 (100.0%)	28 (96.6%)	1 (3.6%)	9 (32.1%)	18 (64.3%)	0 (0.0%)	21 (75.0%)	1 (3.6%)	6 (21.4%)
Others (See Table S3)	61	59 (96.7%)	53 (86.9%)	2 (3.8%)	8 (15.1%)	43 (81.1%)	0 (0.0%)	27 (50.9%)	6 (11.3%)	20 (37.7%)
Overall	**843**	**838 (99.4%)**	**823 (97.6%)**	**15 (1.8%)**	**164 (19.9%)**	**644 (78.3%)**	**163 (19.8%)**	**439 (53.3%)**	**56 (6.8%)**	**327 (39.7%)**

Colon resections: right, left, sigmoid, subtotal and total colectomies. Rectal resections: high, low, ultra-low, abdominoperineal and proctocolectomies

Table 4. Endocrine surgery

		Thromboprophylaxis usage		Chemoprophylaxis timing			Extended	Type		
Operations	**N**	**Mechanical**	**Chemical**	**Pre-op**	**Intra-op**	**Post-op**	**Chemical**	**Enoxaparin**	**Heparin**	**Dalteparin**
Thyroidectomy, total/partial/complete	565	553 (97.9%)	72 (12.7%)	0 (0.0%)	0 (0.0%)	72 (100.0%)	1 (1.4%)	37 (51.4%)	8 (11.1%)	27 (37.5%)
Parathyroidectomy	149	147 (98.7%)	26 (17.4%)	2 (7.7%)	0 (0.0%)	24 (92.3%)	2 (7.7%)	15 (57.7%)	2 (7.7%)	9 (34.6%)
Lymph node clearance, neck	24	23 (95.8%)	8 (33.3%)	0 (0.0%)	1 (12.5%)	7 (87.5%)	0 (0.0%)	5 (62.5%)	1 (12.5%)	2 (25.0%)
Parotidectomy, superficial/total	19	19 (100.0%)	8 (42.1%)	0 (0.0%)	0 (0.0%)	8 (100.0%)	0 (0.0%)	7 (87.5%)	0 (0.0%)	1 (12.5%)
Adrenalectomy	28	28 (100.0%)	23 (82.1%)	1 (4.3%)	5 (21.7%)	17 (73.9%)	1 (4.3%)	12 (52.2%)	7 (30.4%)	4 (17.4%)
Others (See Table S3)	20	15 (75.0%)	2 (10.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)
Overall	**805**	**785 (97.5%)**	**139 (17.3%)**	**3 (2.2%)**	**7 (5.0%)**	**129 (92.8%)**	**4 (2.9%)**	**76 (54.7%)**	**19 (13.7%)**	**44 (31.7%)**

Table 5. Hepatobiliary-pancreas surgery

		Thromboprophylaxis usage		Chemoprophylaxis timing			Extended	Type		
Operations	**N**	**Mechanical**	**Chemical**	**Pre-op**	**Intra-op**	**Post-op**	**Chemical**	**Enoxaparin**	**Heparin**	**Dalteparin**
Cholecystectomy	1792	1718 (95.9%)	1468 (81.9%)	341 (24.7%)	532 (38.5%)	595 (43.1%)	7 (0.5%)	817 (59.1%)	85 (6.2%)	480 (34.7%)
Liver resection	137	137 (100.0%)	136 (99.3%)	1 (0.7%)	57 (41.9%)	78 (57.4%)	57 (41.9%)	89 (65.4%)	18 (13.2%)	28 (20.6%)
Whipple's pancreaticoduodenectomy	71	71 (100.0%)	71 (100.0%)	4 (5.6%)	30 (42.3%)	37 (52.1%)	19 (26.8%)	29 (40.8%)	16 (22.5%)	26 (36.6%)
Distal pancreatectomy +/- splenectomy	35	35 (100.0%)	35 (100.0%)	1 (2.9%)	12 (34.3%)	22 (62.9%)	15 (42.9%)	22 (62.9%)	8 (22.9%)	5 (14.3%)
Others (See Table S3)	38	38 (100.0%)	35 (92.1%)	1 (2.9%)	14 (40.0%)	20 (57.1%)	2 (5.7%)	21 (60.0%)	4 (11.4%)	10 (28.6%)
Overall	**2073**	**1999 (96.4%)**	**1745 (84.2%)**	**348 (21.0%)**	**645 (38.9%)**	**752 (45.4%)**	**100 (6.0%)**	**978 (59.0%)**	**131 (7.9%)**	**548 (33.1%)**

Table 6. Non-specialist general surgery

		Thromboprophylaxis usage		Chemoprophylaxis timing			Extended	Type		
Operations	**N**	**Mechanical**	**Chemical**	**Pre-op**	**Intra-op**	**Post-op**	**Chemical**	**Enoxaparin**	**Heparin**	**Dalteparin**
Ventral hernia repair	541	525 (97.0%)	392 (72.5%)	7 (1.8%)	163 (41.6%)	222 (56.6%)	1 (0.3%)	243 (62.0%)	29 (7.4%)	120 (30.6%)
Lymph node biopsy, groin, non-sentinel	37	24 (64.9%)	5 (13.5%)	0 (0.0%)	3 (60.0%)	2 (40.0%)	2 (40.0%)	4 (80.0%)	0 (0.0%)	1 (20.0%)
Laparotomy, diagnostic or staging	35	35 (100.0%)	32 (91.4%)	5 (15.6%)	8 (25.0%)	19 (59.4%)	6 (18.8%)	24 (75.0%)	2 (6.3%)	6 (18.8%)
Small bowel resection	33	31 (93.9%)	30 (90.9%)	0 (0.0%)	10 (33.3%)	20 (66.7%)	3 (10.0%)	18 (60.0%)	1 (3.3%)	11 (36.7%)
Others (See Table S3)	4	3 (75.0%)	0 (0.0%)	-	-	-	-	-	-	-
Overall	**650**	**618 (95.1%)**	**459 (70.6%)**	**12 (2.6%)**	**184 (40.1%)**	**263 (57.3%)**	**12 (2.6%)**	**290 (63.2%)**	**33 (7.2%)**	**138 (30.1%)**

Table 7. Bleeding and clinical VTE

Operations	N Patients	Clinical VTE N (%)	Overall bleeding N (%)	Major bleeding N (%)
Bariatric and Upper GI				
Gastric sleeve	307	0 (0.0%)	7 (2.3%)	7 (100.0%)
Gastric bypass	112	1 (0.9%)	4 (3.6%)	4 (100.0%)
Fundoplication/hiatus hernia repair	138	1 (0.7%)	2 (1.4%)	2 (100.0%)
Oesophago-gastric resections	61	1 (1.6%)	9 (14.8%)	8 (88.9%)
Others	57	0 (0.0%)	2 (3.5%)	1 (50.0%)
Overall	**675**	**3 (0.4%)**	**24 (3.6%)**	**22 (91.7%)**
Breast				
Wide local excision +/- SLNB or ALND	449	1 (0.2%)	9 (2.0%)	6 (66.7%)
Mastectomy +/- SLNB or ALND	322	1 (0.3%)	22 (6.8%)	20 (90.9%)
Excisional biopsy	158	0 (0.0%)	2 (1.3%)	1 (50.0%)
Others	114	0 (0.0%)	5 (4.4%)	0 (0.0%)
Overall	**1043**	**2 (0.2%)**	**38 (3.6%)**	**27 (71.1%)**
Colorectal				
Rectal resection	305	6 (2.0%)	17 (5.6%)	14 (82.4%)
Colonic resection	250	4 (1.6%)	18 (7.2%)	17 (94.4%)
Ileostomy closures	82	0 (0.0%)	2 (2.4%)	2 (100.0%)
Others	109	0 (0.0%)	2 (1.8%)	0 (0.0%)
Overall	**746**	**10 (1.3%)**	**39 (5.3%)**	**33 (84.6%)**
Endocrine				
Thyroidectomy	565	0 (0.0%)	7 (1.2%)	5 (71.4%)
Parathyroidectomy	136	0 (0.0%)	1 (0.7%)	1 (100.0%)
Others	72	0 (0.0%)	3 (4.2%)	3 (100.0%)
Overall	**773**	**0 (0.0%)**	**11 (1.4%)**	**9 (81.8%)**
General				
Ventral hernia repairs	536	1 (0.2%)	22 (4.1%)	10 (45.5%)
Others	119	1 (0.8%)	12 (10.1%)	10 (83.3%)
Overall	**655**	**2 (0.3%)**	**34 (5.2%)**	**20 (58.8%)**
Hepatobiliary-pancreas				

Cholecystectomy	1747	5 (0.3%)	42 (2.4%)	21 (50.0%)
Liver resection	133	2 (1.5%)	9 (6.8%)	9 (100.0%)
Whipple's pancreaticoduodenectomy	71	0 (0.0%)	6 (8.5%)	6 (100.0%)
Others	69	1 (1.4%)	6 (8.7%)	6 (100.0%)
Overall	**2020**	**8 (0.4%)**	**63 (3.1%)**	**42 (66.7%)**

ALND: Axillary lymph node dissection. SLNB: sentinel lymph node biopsy