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Robotic Total Pancreatectomy with Splenectomy. Technique and Outcomes

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Abstract

BACKGROUND—Robotic total pancreatectomy(TP) represents a minimally invasive approach to a major intra-abdominal operation. Its utility, technique and outcomes are evolving.

METHODS—In this video, we describe a systematic approach to a robotic total pancreatectomy performed for multifocal intraductal papillary mucinous neoplasm (IPMN). Additionally, we reviewed the National Cancer Database(NCDB) to examine the outcomes of robotic TP compared to laparoscopic and open TP between 2010–2014.

RESULTS—The patient is a 61-year-old female who was diagnosed with multifocal IPMN. A total of 6 robotic ports were placed and the da Vinci Xi robotic system was used with the patient supine. The approach entailed: 1) Diagnostic laparoscopy;2) Entry into the lesser sac;3) Division of the short gastric vessels;4) Exposure and dissection of the inferior pancreas border;5) Dissection and transection of the splenic artery;6) Mobilization of the pancreas tail/spleen;7) Exposure of the splenic vein-superior mesenteric vein confluence;8) Kocher maneuver;9) Release of the Ligament of Treitz and transection of the proximal jejunum;10) Transection of the distal stomach;11) Portal lymphadenectomy;12) Dissection and transection of the gastroduodenal artery; 13) Superior Mesenteric Vein Exposure/Dissection of the uncinate process;14) Hepaticojejunostomy;15) Cholecystectomy;16) Gastrojejunostomy. NCDB database review of 73 patients who underwent robotic TP revealed similar rates of margin negative resections and retrieved lymph nodes between robotic, laparoscopic and open TP, whereas robotic and laparoscopic TP were associated with shorter in-hospital stay and reduced mortality at 30 and 90 days compared to open TP. Overall median survival of pancreatic adenocarcinoma patients who underwent TP was similar between robotic, laparoscopic and open approaches.

CONCLUSION—Robotic total pancreatectomy with splenectomy offers a minimally invasive approach to a major abdominal operation and is feasible in a stepwise, reproducible technique. It is associated with improved postoperative outcomes and equivalent oncologic outcomes compared to open TP.

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Disclosures

Ioannis T. Konstantinidis, Zeljka Jutric, Oliver S. Eng, Susanne G. Warner, Laleh G. Melstrom, Yuman Fong, Byrne Lee, Gagandeep Singh have no conflicts of interest. Additionally, the authors do not have any conflict of interest with Intuitive Surgical.

Keywords

robotic total pancreatectomy; National Cancer Database; postoperative outcomes

Introduction

Total pancreatectomy (TP) is indicated for the treatment of pancreatic cancer when most of the pancreas is involved, for multifocal pathologies involving the entire gland, such as intraductal papillary mucinous neoplasm (IPMN), or uncommonly in refractory chronic pancreatitis. Its benefits have to be weighed carefully against its significant morbidity, which is the highest amongst pancreatectomies [1–4].

Robotic assisted pancreatic surgery is increasingly being utilized. Most reports come from a few experienced centers [5–7]. The operative technique is evolving and the short and long term outcomes are unknown. Herein we describe our technique with a robotic assisted total pancreatectomy for multifocal branch duct IPMN involving the entire pancreas. Additionally, we reviewed the National Cancer Database to examine the nationwide utilization and outcomes of robotic total pancreatectomy. In order to assess the long term oncologic outcome of robotic total pancreatectomy we examined the survival of patients diagnosed with adenocarcinoma of the pancreas.

Methods

The National Cancer Database (NCDB) is a hospital-based cancer registry sponsored by a joint program between the American College of Surgeons Commission on Cancer (CoC) and the American Cancer Society [8]. It represents approximately 70% of all newly diagnosed cancer cases nationwide from more than 1,500 hospitals. The surgical approach (open, robotic, laparoscopic) is available for the period 2010–2014. The Pancreatic Participant Use Data File (PUF) is a Health Insurance Portability and Accountability Act (HIPAA)-compliant data file containing de-identified data. Institutional review board approval was not required for this study because no patient identifiers were examined.

For the purpose of this study, we included operations of primary site codes 40: total pancreatectomy and 60: total pancreatectomy and subtotal gastrectomy or duodenectomy. The postoperative outcomes of robotic TP were compared to laparoscopic TP and open TP. Robotic and laparoscopic operations categorized as converted to open were examined with the open TP.

The survival of patients diagnosed with adenocarcinoma utilizing the histology codes 8140 for adenocarcinoma and 8500 for ductal carcinoma was examined. We elected to limit the survival analysis to pancreatic adenocarcinoma patients as these represented the majority (73%) of patients who underwent a robotic total pancreatectomy. Patients with histology codes 8453, intraductal papillary mucinous carcinoma and 8480 mucinous adenocarcinoma represented only 8% of the patients who underwent a robotic total pancreatectomy.

Continuous variables are presented as median and range or mean and standard deviation. Categorical variables are presented as proportions. We assessed group differences using Fisher exact or Pearson x^2 test for categorical variables. Continuous variables were compared with the student's t test when the distribution was normal, or the Wilcoxon rank-sum test and Kruskal-Wallis test when the distribution was not normal. Survival curves were constructed with the Kaplan Meier method and differences assessed with the log rank test. Statistical analysis was performed using SPSS Statistics v23 software (IBM Corp, Armonk, NY).

Results

Surgical technique (video)

A 61-year-old female with multifocal branch duct intraductal papillary mucinous neoplasm (IPMN) involving the entire pancreas was evaluated. She was a type 1 diabetic on an insulin pump with a history of robotic total abdominal hysterectomy for stage 1 endometrial cancer. Fine needle aspiration of a complex cyst located at the pancreas neck was significant for a CEA of 2080, however the pancreatic cysts did not harbor "high risk stigmata" [9], therefore the option of expectant management was discussed with her and she elected to proceed with a robotic total pancreatectomy to minimize her risk of developing pancreatic cancer. The patient was positioned supine. We utilized the 30 degree, 8mm Endoscope, 6 robotic ports, and the da Vinci Xi robotic system. We proceeded in the following stepwise fashion:

1. *Diagnostic laparoscopy.* We did not identify any evidence of suspicious extrapancreatic disease or other pathologies.

2. *Entry into the lessec sac.* The gastrocolic ligament was divided and the anterior surface of the body and tail of the pancreas was exposed.

3. *Division of the short gastric vessels.* We divided the short gastric vessels with the use of the robotic Vessel Sealer all the way to the angle of His.

4. *Exposure and dissection of the inferior pancreas border.* We dissected the inferior pancreatic border from the transverse colon mesentery with the use of the Hot Shears (Monopolar Curved Scissors).

5. *Dissection and transection of the splenic artery.* The splenic artery (SA) was circumferentially dissected at the superior edge of the pancreas. This was achieved with the use of the long Bipolar Grasper. We transected the SA with the use of the Endo GIA Stapler with a Tan Load.

6. *Mobilization of the pancreas tail/spleen.* We completed the mobilization of the inferior margin of the pancreas towards the splenic hilum with the use of the Hot Shears. For better traction and exposure we passed a Penrose around the pancreas and we applied traction towards the right side of the patient. The splenocolic ligament was divided with the robotic Vessel Sealer to prevent bleeding from vessels running along the ligament. The remaining retroperitoneal attachments of the pancreas were divided and the tail of the pancreas and spleen were completely mobilized.

7. *Exposure of the splenic vein (SV)-superior mesenteric vein (SMV) confluence.* The SV was isolated and divided with the use of the Endo GIA Stapler with a Tan Load.

8. *Kocher maneuver.* The first and second portions of the duodenum were mobilized with the use of the Hot Shears.

9. *Release of the Ligament of Treitz and transection of proximal jejunum.* The ligament of Treitz was divided with the use of the robotic Vessel Sealer. The jejunum was pulled to the right side beneath the root of the mesentery, the proximal 10–15cm were dissected and transected with the Endo GIA Stapler with a Tan Load.

10. *Transection of the distal stomach.* We used the Endo GIA Stapler with a Purple Load for this purpose.

11. *Portal lymphadenectomy.* This was achieved with the use of the Cautery Hook.

12. *Dissection and transection of the gastroduodenal artery.* The gastroduodenal artery (GDA) was bluntly dissected with the use of the Long Bipolar Grasper. We passed a 2-0 Silk tie around the vessel to facilitate exposure. The Endo GIA Stapler with a Tan Load was utilized the divide the GDA.

13. *Superior Mesenteric Vein Exposure/Dissection of the uncinate process.* A tunnel was created underneath the neck of the pancreas along the mesenteric-portal axis. The SMV was identified and dissected from the posterior neck of the pancreas carefully. The uncinate process was dissected off the SMV. The common bile duct was divided at this point. Weck Hem-0-lok medium-large polymer clips were placed as needed before division of large vessels for additional safety. The first jejunal branch inferiorly was preserved. The final portion of the uncinate process was excised along the PV with the Endo GIA Stapler with a Tan Load. We divided the rest of the pancreatic attachments with the robotic vessel sealer and the specimen was placed in a retrieval bag and removed.

14. *Hepaticojejunostomy.* We performed an end to side hepaticojejunostomy with the use of interrupted 4-0 PDS sutures for the anterior row and running for the posterior row.

15. *Cholecystectomy.* Subsequently we completed the cholecystectomy with the use of the hook electrocautery in the standard fashion. The gallbladder was used for retraction as needed hence was divided last.

16. *Gastrojejunostomy.* We performed an antecolic end to side gastrojejunal anastomosis approximately 45–50cm distal to the hepaticojejunostomy (not shown in this video).

The patient was discharged home on postoperative day 9 after an uneventful postoperative course. She returned bowel function on postoperative day 5 after which she was transitioned to oral pain medications and advanced to a diabetic diet. The rest of her hospitalization was related to optimization of her glycemic management. Final pathology was consisted with multifocal branch duct IPMN without evidence of invasive cancer and 0/26 nodes negative for cancer.

National Cancer Database Data

Clinicopathologic Characteristics—During the period 2010–2014, we identified 3876 patients who underwent total pancreatectomy (TP) with/without subtotal gastrectomy or duodenectomy of which 73(1.9%) were robotic assisted, 455(11.7%) laparoscopic and 3348(86.4%) open. The 73 patients who underwent a robotic TP represent the focus of this study. The utilization of robotic TP tripled during the study period from 8 cases in 2010 to 24 in 2014. Table 1 illustrates the clinicopathologic data of this cohort. Intraductal papillary mucinous carcinoma and mucinous adenocarcinoma patients represented only 8% of the robotic total pancreatectomies cohort whereas the majority (73%) suffered from pancreatic ductal adenocarcinoma. The median age of the patients was similar between robotic, laparoscopic and open TP, most patients were Caucasian with a Charlson index 0, and underwent TP at an academic research program.

Postoperative Results—Overall, the percentage of margin negative resections was similar between robotic, laparoscopic and open TP (89.6% vs 89.8% vs 85.9%, respectively; p=0.14). The median number of lymph nodes retrieved was similar (14 vs 14 vs 15, respectively; p=0.06). The median duration of in-hospital stay was improved for robotic and laparoscopic TP compared to open TP (8 vs 7 vs 9 days, respectively; p<0.001). Readmission rates were similar with a trend for lower readmission rates for robotic and laparoscopic TP vs open TP (6.8% vs 7.2% vs 9.6%, respectively; p=0.2), whereas 30d and 90d mortality rates were improved with robotic and laparoscopic TP versus open TP (30d: 2% vs 1.2% vs 4.8%, respectively; p=0.006 and 90d: 4.3% vs 5% vs 9.4%, respectively; p=0.02). The association of robotic TP with decreased mortality was significant even after multivariate logistic regression analysis (table2).

Long term survival for Pancreatic Ductal Adenocarcinoma—The long term survival of patients with pancreatic ductal adenocarcinoma was examined. This was the most common indication for robotic TP (72.6%). The median overall survival was similar between robotic, laparoscopic and open TP performed for pancreatic adenocarcinoma (22.5 vs 22.4 vs 20.2 months respectively, p=0.22; Figure 1).

Discussion

In this report, we describe a stepwise approach to robotic total pancreatectomy (TP), and we provide nationwide data on its utilization, short- and long-term outcomes. Evaluation of the National Cancer Database on TP cases, revealed that the use of robotic TP was associated with decreased hospital stay and postoperative mortality at 30 and 90 days compared to open TP and similar to laparoscopic TP. Its oncologic outcome was equivalent to laparoscopic and open TP with similar rates of margin negative resections and retrieved lymph nodes. Additionally, the median overall survival after TP for pancreatic ductal adenocarcinoma was comparable between the three approaches.

In our video, we performed a robotic TP for multifocal branch duct IPMN. The majority of robotic TPs in the NCDB cohort were performed for pancreatic adenocarcinoma. Total pancreatectomy is considered for tumors involving the entire pancreas such as pancreatic cancer or main duct IPMN, for multifocal tumors i.e. branch duct IPMN, neuroendocrine tumors or metastases i.e. from renal cell cancer, for history of familial pancreatic cancer and presence of multifocal PanIN, or for patients with chronic pancreatitis and intractable pain with possible islet cell autotransplantation [1, 6].

From a technical perspective, the application of robotic technology did not alter the course of total pancreatectomy in our case, but it conferred benefits associated with the use of the robotic platform. These include the superior visualization (increased magnification, 3-dimensional view, improved depth of perception), such as during the creation of the retropancreatic/portal vein tunnel, and the ergonomical advantages (seven ranges of motion versus the four of laparoscopy, tremor filtration, articulating instruments), and render the robot beneficial for precise surgical dissection and fine suturing, for example during the bilioenteric anastomosis in our video. The benefits of robotic technology during total pancreatectomy have been emphasized in existing small case series [6, 10]. When robotic TP is performed for islet cell autotransplantation, the blood supply to the pancreas is preserved until the very end of the operation to maximize the islet yield [11]. We did not need to perform a vascular resection in our case, however the feasibility of robotic assisted vascular resections during pancreatic surgery has been demonstrated therefore the utilization of robotic surgery should not be precluded on the basis of vascular resection necessity [12]. However, robotic surgery is not without hazards. Injury to major structures such as the portal vein can result in operative mortality [13, 14]. It is imperative that major resections are being performed in centers with experience and the procedure should be converted when there are safety concerns.

With appropriate experience, robotic pancreatic surgery can be performed with acceptable morbidity [7]. In our report, robotic and laparoscopic TP were associated with shorter hospital stay and improved 30 and 90 day mortality compared to open TP.

We similarly have shown improved postoperative outcome and shorted hospital stay for minimally invasive distal pancreatectomies with frail patients deriving the greatest benefit [15]. Boggi et al. in a case-matched study of 11 robotic versus open equal TP found lower blood loss with the robotic TP and similar postoperative morbidity [16]. Zureikat et al. in a multi-institutional comparison of robotic versus open pancreaticoduodenectomy found reduced blood loss and major complications with the robotic approach [17]. Finally, Liu et al. [18] in a retrospective study comparing 27 robot-assisted to 25 laparoscopic pancreaticoduodenectomies found reduced blood loss, and shorter hospital stay associated with the robot-assisted group. Larger studies are needed before definite conclusions can be made. It is also equally important to realize that robotic assisted pancreatic surgery is associated with a significant learning curve with improvement in operative results (conversions to open surgery, estimated blood loss, operative time) and readmission rates after the first 20–40 cases [19, 20].

In this study, analysis of NCDB data from 3876 patients that had undergone TP demonstrated oncologic equivalence between robotic, laparoscopic and open TP, with similar rates of margin negative resections and retrieved lymph nodes. Additionally, the median overall survival when TP was performed for pancreatic adenocarcinoma was similar between the three approaches. The application of minimally invasive pancreatic surgery is associated with equivalent oncologic outcomes to open surgery with regards to the completion of resection and extent of lymphadenectomy [17].

Conclusion

In conclusion, we describe and illustrate with an accompanying video a stepwise approach to a robotic total pancreatectomy performed for a multifocal IPMN. NCDB data support that the utilization of robotic TP has tripled from 2010 to 2014 and is associated, similarly to laparoscopic TP, with decreased hospitalization and postoperative mortality compared to open TP. Its long term oncologic outcome appears equivalent to laparoscopic and open TP when performed for pancreatic adenocarcinoma.

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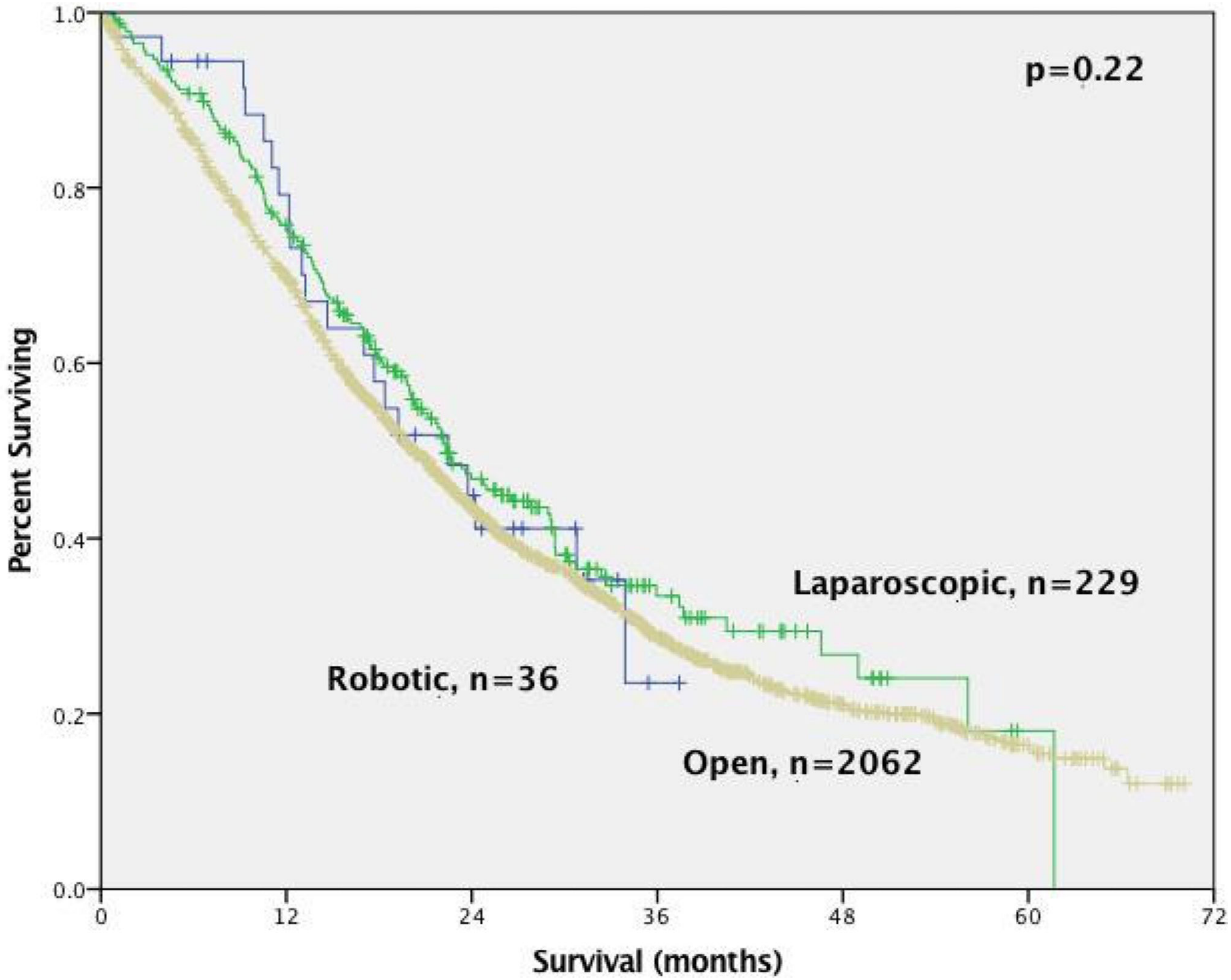
p=0.22
Percent Surviving
1.0
0.8
0.6
0.4
0.2
0.0
0
12
24
36
48
60
72
Survival (months)
Laparoscopic, n=229
Robotic, n=36
Open, n=2062

Figure 1.

Table 1

Clinicopathologic Characteristics of 3876 patients who underwent total pancreatectomy (TP) with/without subtotal gastrectomy or duodenectomy.

Variable	Robotic TP (N=73)	Laparoscopic TP (N=455)	Open TP (N=3348)	p
Age, mean (SD), y	67(22–89)	67(18–89)	66(18–90)	NS
Female gender	38(52.1)	214(47)	1603(47.9)	NS
Race				
Caucasian (ref)	60(82.2)	376(82.6)	2821(84.3)	NS
African American	8(11)	46(10.1)	353(10.5)	
Other	5(6.8)	33(7.3)	174(5.2)	
Insurance				
Private	31(42.5)	162(35.6)	1272(38)	NS
Medicaid	3(4.1)	24(5.3)	155(4.6)	
Medicare	38(52.1)	246(54.1)	1696(50.7)	
Other	1(1.4)	23(5)	225(6.7)	
Median Income	N=73	N=452	N=3327	0.03
<38,000	14(19.2)	57(12.6)	544(16.4)	
38,000–47,999	6(8.2)	99(21.9)	758(22.8)	
48,000–62,999	26(35.6)	129(28.5)	892(26.8)	
>63,000	27(37)	167(36.9)	1133(34.1)	
Charlson-Deyo Comorbidity Score				
0	47(64.4)	281(61.8)	2156(64.4)	NS
1	18(24.7)	126(27.7)	929(27.7)	
2	8(11)	48(10.5)	263(7.9)	
Examined Lymph Nodes	14(0–49)	14(0–56)	15(0–90)	NS
Surgical Margins	N=67	N=411	N=3048	NS
R0	60(89.6)	369(89.8)	2617(85.9)	
R1	7(10.4)	39(9.5)	417(13.7)	
R2	0	3(0.7)	14(0.5)	
Hospital Type	N=71	N=445	N=3278	NS
Academic/Research NCI designated	41(57.7)	262(58.9)	1974(60.2)	
Integrated Network Cancer	12(16.9)	47(10.6)	400(12.2)	
Comprehensive Community Cancer	18(25.4)	130(29.2)	830(25.2)	
Community Cancer	0	6(1.3)	74(2.3)	
In-hospital stay, d	8	7	9	<0.001
Readmission within 30d	5/73(6.8)	32/447(7.2)	320/3005(9.6)	NS
30d Mortality	1/49(2)	4/340(1.2)	130/2710(4.8)	0.006
90d Mortality	2/47(4.3)	17/337(5)	252/2682(9.4)	0.02

y=years, d= days, SD=standard deviation

Table 1

Multivariate logistic regression analysis for predictors of 90-day mortality

Variable	OR (95% CI)	p
Year of diagnosis		
2010 (ref)	1.00	
2011	0.82(0.71–0.95)	0.008
2012	0.79(0.69–0.92)	0.002
2013	0.83(0.72–0.96)	0.013
Age	1.04(1.04–1.05)	<0.001
Gender		
Male (ref)	1.00	
Female	0.89(0.8–0.99)	0.029
Race		
White (ref)	1.00	
Black	1.08(0.91–1.29)	0.4
Hispanic	1.17(0.92–1.5)	0.2
Charlson-Deyo Comorbidity Score		
0 (ref)	1.00	
1	0.95(0.84–1)	0.4
≥2	1.4(1.18–1.66)	<0.001
Tumor size (cm)		
>0 to <1.0 (ref)	1.00	
1.0 to <2.0	1.06(0.7–1.61)	0.8
2.0 to <3.0	1.4(0.95–2)	0.09
3.0 to <5.0	1.77(1.21–2.59)	0.003
≥5	2.34(1.59–3.45)	<0.001
Surgery approach		
Robotic (ref)	1.00	
Laparoscopic	1.36(0.88–2.1)	0.17
Open	1.77(1.16–2.69)	0.008
Facilty/Type of program		
Community cancer (ref)	1.00	
Comprehensive Community Cancer	0.56(0.41–0.76)	<0.001
Academic/Research	0.38(0.28–0.51)	<0.001
Integrated Network	0.45(0.32–0.65)	<0.001