Available online at www.sciencedirect.com

ScienceDirect

EJSO the Journal of Cancer Surgery

EJSO xx (2016) 1–6 www.ejso.com

Who may benefit from robotic gastrectomy?: A subgroup analysis of multicenter prospective comparative study data on robotic versus laparoscopic gastrectomy

J.M. Park [a], H.I. Kim [b], S.U. Han [c], H.K. Yang [d], Y.W. Kim [e], H.J. Lee [d], J.Y. An [b], M.C. Kim [f], S. Park [g], K.Y. Song [h], S.J. Oh [i], S.H. Kong [d], B.J. Suh [i], D.H. Yang [j], T.K. Ha [k], W.J. Hyung [b], K.W. Ryu [e,*]

[a] *Department of Surgery, Chung-Ang University College of Medicine, Seoul, South Korea*
[b] *Department of Surgery, Yonsei University College of Medicine, Seoul, South Korea*
[c] *Department of Surgery, Ajou University College of Medicine, Gyeonggido, South Korea*
[d] *Department of Surgery, Seoul National University College of Medicine, Seoul, South Korea*
[e] *Center for Gastric Cancer, National Cancer Center, Gyeonggido, South Korea*
[f] *Department of Surgery, Dong-A University College of Medicine, Busan, South Korea*
[g] *Department of Surgery, Korea University College of Medicine, Seoul, South Korea*
[h] *Department of Surgery, The Catholic University of Korea, Seoul, South Korea*
[i] *Department of Surgery, Inje University College of Medicine, Busan, South Korea*
[j] *Department of Surgery, Hallym University College of Medicine, Seoul, South Korea*
[k] *Department of Surgery, Hanyang University College of Medicine, Seoul, South Korea*

Accepted 14 July 2016
Available online ■ ■ ■

Abstract

Aims: Robotic gastrectomy for gastric cancer has been proven to be a feasible and safe minimally invasive procedure. However, our previous multicenter prospective study indicated that robotic gastrectomy is not superior to laparoscopic gastrectomy. This study aimed to identify which subgroups of patients would benefit from robotic gastrectomy rather than from conventional laparoscopic gastrectomy.
Methods: A prospective multicenter comparative study comparing laparoscopic and robotic gastrectomy was previously conducted. We divided the patients into subgroups according to obesity, type of gastrectomy performed, and extent of lymph node dissection. Surgical outcomes were compared between the robotic and laparoscopic groups in each subgroup.
Results: A total of 434 patients were enrolled into the robotic (n = 223) and laparoscopic (n = 211) surgery groups. According to obesity and gastrectomy type, there was no difference in the estimated blood loss (EBL), number of retrieved lymph nodes, complication rate, open conversion rate, and the length of hospital stay between the robotic and laparoscopic groups. According to the extent of lymph node dissection, the robotic group showed a significantly lower EBL than did the laparoscopic group after D2 dissection ($P = 0.021$), while there was no difference in EBL in patients that did not undergo D2 dissection ($P = 0.365$).
Conclusion: Patients with gastric cancer undergoing D2 lymph node dissection can benefit from less blood loss when a robotic surgery system is used.

Keywords: Gastric cancer; Robotic surgery; Laparoscopy; Surgical outcome

Introduction

Laparoscopic gastrectomy has now gained worldwide acceptance for the treatment of early gastric cancer. A large

* Corresponding author. Fax: +82 31 920 0069.
E-mail address: docryu@korea.com (K.W. Ryu).

http://dx.doi.org/10.1016/j.ejso.2016.07.012

number of non-randomized trials, randomized trials, and meta-analyses have confirmed that laparoscopic gastrectomy is safe and feasible, with advantages such as less pain, earlier recovery, and fewer postoperative complications compared to open gastrectomy.[1–4]

However, laparoscopic gastrectomy still has limitations such as the limited movement of the instrument, amplification of physiologic tremor, and unstable video images. A robotic system has been adopted to overcome these technical difficulties in conventional laparoscopic gastrectomy for gastric cancer, with three-dimensional high-definition visualization, a wristed instrument without tremor, more intuitive instrument control with increased dexterity, and better ergonomics.[5] Robotic gastrectomy has also been proven to be feasible and safe from the standpoint of short-term surgical outcomes.[6–9] However, the benefits of robotic gastrectomy have not been consistent across reports or even in meta-analysis.[10–13] Therefore, the benefits of robotic gastrectomy remain controversial. Moreover, a recent multicenter prospective study did not show any superiority of robotic gastrectomy in terms of short-term outcomes.[14]

Thus, we designed the present study as a subgroup analysis following a multicenter prospective study that did not show an advantage of robotic gastrectomy over conventional laparoscopic gastrectomy.[14] This study aimed to identify which subgroups of patients would benefit from robotic gastrectomy rather than from conventional laparoscopic gastrectomy.

Materials and methods

Patients

Between May 2011 and December 2012, we conducted a prospective multicenter study comparing robotic gastrectomy with laparoscopic gastrectomy performed on patients with gastric cancer at 11 hospitals by 17 surgeons. The inclusion criteria and matching method have been described previously.[14] The patients selected the type of surgery after they received a comprehensive explanation of each procedure. The patients were matched according to surgeon, extent of gastric resection, and sex. After an enrolled patient underwent robotic gastrectomy, screening was carried out to identify a patient of the same sex who was expected to undergo the same extent of resection among the patients who were scheduled to undergo laparoscopic gastrectomy by the same surgeon. Candidate patients identified for matching were asked to participate in the study. All patients provided a written informed consent, and the study was approved by the Institutional Review Boards of all participating institutions.

Subgroup analysis

Surgery for obese patients, extended (D2) lymph node dissection, and total gastrectomy were considered factors contributing to more complications and greater technical difficulty during laparoscopic gastrectomy. For these reasons, we divided the patients into subgroups according to obesity, extent of gastric resection, and extent of lymph node dissection.

Obesity status was classified using the body mass index (BMI). Patients were categorized to the non-obese group if they had BMIs within the normal range or were underweight (<25 kg/m^2) and into the obese group if they had BMIs above the normal range (≥ 25 kg/m^2) according to the World Health Organization definition of obesity in the Asia–Pacific region. Patients were divided into a total gastrectomy group and partial gastrectomy group, which included distal subtotal gastrectomy, proximal gastrectomy, and pylorus-preserving gastrectomy. They were also categorized into a D2 group and non-D2 group including D1 or D1+ lymphadenectomy. We utilized the Japanese gastric cancer treatment guidelines 2010 to define the extent of lymph node dissection.[15] In each subgroup, surgical outcomes, including the operative time, complication rate, estimated blood loss (EBL), open conversion rate, number of retrieved lymph nodes (RLN), and length of hospital stay, were compared between the robotic and laparoscopic groups as parameters representing the benefits of robotic gastrectomy.

Statistical analysis

All subgroup outcomes underwent intention-to-treat analysis. Categorical variables were compared using the chi-square test, while continuous variables were compared with the independent sample *t*-test. Two-sided p-values were calculated for all tests. A *P*-value of less than 0.05 was considered statistically significant. All analyses were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Overall results

A total of 434 patients (223 robotic and 211 laparoscopic gastrectomies) were enrolled.

The overall analysis of the enrolled patients has been described previously.[14] In summary, the characteristics of the two groups were similar with the exception of age, medical comorbidity, and disease stage. Patients in the robotic group were younger ($P = 0.024$) and had fewer medical comorbidities ($P = 0.025$) than those in the laparoscopic group. The tumors in the robotic group had more advanced T and N stages ($P = 0.013$, $P = 0.012$). The operative time was significantly longer for the patients in the robotic group ($P < 0.001$). There was no difference in the complication rate ($P = 0.619$), EBL ($P = 0.296$), RLN number ($P = 0.514$), length of the hospital stay

Please cite this article in press as: Park JM, et al., Who may benefit from robotic gastrectomy?: A subgroup analysis of multicenter prospective comparative study data on robotic versus laparoscopic gastrectomy, Eur J Surg Oncol (2016), http://dx.doi.org/10.1016/j.ejso.2016.07.012

($P = 0.889$), and open conversion rate ($P = 0.999$) between the robotic and laparoscopic gastrectomy groups.[14]

Subgroup analysis

Based on obesity and the extent of gastric resection, the operative time was significantly longer for robotic gastrectomy than for laparoscopic gastrectomy in both subgroups. There was no difference in EBL, RLN number, complication rate, open conversion rate, and the length of hospital stay between the robotic and laparoscopic groups in both subgroups (Tables 1 and 2).

According to the extent of lymph node dissection, the operative time was significantly longer for robotic gastrectomy than for laparoscopic gastrectomy in both subgroups. There was no difference in RLN number, complication rate, open conversion rate, and length of hospital stay between the robotic and laparoscopic groups, regardless of the extent of lymph node dissection. However, the robotic group showed a significantly lower EBL than did the laparoscopic group in the D2 dissection subgroup (98.9 mL in the robotic group and 140.5 mL in the laparoscopic group, $P = 0.021$), while there was no difference in EBL within the non-D2 subgroup (96.5 mL in the robotic group and 82.6 mL in the laparoscopic group, $P = 0.365$, Table 3).

Discussion

Although robotic surgery has theoretical advantages over conventional laparoscopy and a number of studies have reported the feasibility of applying a robotic surgical system for gastric cancer surgery, few have presented clear evidence of its superiority.[6–9] For instance, our group conducted a multicenter prospective study that identified no significant differences in postoperative outcomes including complications, the amount of intraoperative blood loss, and the number of retrieved lymph nodes between the robotic and laparoscopic gastrectomy groups whereas the robotic surgery group showed significantly longer operation time and significantly higher total cost.[14] High cost still remains a major drawback of robotic surgery, and thus the technique is not used for all patients with gastric cancer given its unclear benefit and high cost. Therefore, we aimed to determine whether specific patient groups might benefit from robotic surgery. We designed this study to compare the surgical outcomes between subgroups of patients who underwent robotic and laparoscopic gastrectomy in a multicenter prospective study.

According to our results, robotic assistance did not improve the quality of lymph node dissection or reduce blood loss during lymphadenectomy for obese patients. This is possibly because the surgeons in this study had considerable experience with laparoscopic gastrectomy and were already performing high-quality procedures in obese patients. Thus, we could not identify any additional benefit from robotic procedures for obese patients. The present study is not the first to examine this issue via subgroup analyses. Lee et al.[16] suggested that the benefits of robotic surgery were more evident in obese patients because the differences in the rate of inadequately retrieved lymph nodes because of high BMI disappeared with the application of robotic surgery. They also reported that for patients with BMIs greater than 25 kg/m^2, the blood loss of those in the robotic group was less than that of those in the laparoscopic group. However, Park et al.[17] reported that robotic assistance did not improve surgical outcomes compared with the laparoscopic method in obese patients and that its benefit in terms of greater lymph node retrieval was

Table 1
Comparison of robotic and laparoscopic gastrectomy by BMI status.

Characteristic	Obese (BMI ≥ 25, n = 130)			Non-obese (BMI < 25, n = 304)		
	Robot (n = 68)	Laparoscopy (n = 62)	*P*-value	Robot (n = 155)	Laparoscopy (n = 149)	*P*-value
Age (years)	53.4 ± 12.0	57.4 ± 10.6	0.044	52.1 ± 11.0	55.2 ± 11.3	0.015
Male gender	49 (72.1%)	40 (64.5%)	0.355	82 (52.9%)	86 (57.7%)	0.399
Stage			0.434			0.002
IA	51 (75.0%)	52 (83.9%)		103 (66.5%)	125 (83.9%)	
IB	8 (11.8%)	4 (6.5%)		18 (11.6%)	9 (6.0%)	
II/III	9 (13.2%)	6 (9.7%)		34 (21.9%)	15 (10.1%)	
Gastric resection			0.420			0.298
Total	11 (16.2%)	7 (11.3%)		31 (20.0%)	23 (15.4%)	
Partial	57 (83.8%)	55 (88.7%)		124 (80.0%)	126 (84.6%)	
Lymph node dissection			0.268			0.065
D2	26 (38.2%)	18 (29.0%)		84 (54.2%)	65 (43.6%)	
D1 or D1+	42 (61.8%)	44 (71.0%)		71 (45.8%)	84 (56.4%)	
Operative time (min)	259.6 ± 77.8	196.2 ± 67.8	<0.001	222.9 ± 59.9	182.5 ± 59.2	<0.001
Blood loss (ml)	106.5 ± 123.4	95.0 ± 93.9	0.552	101.7 ± 132.3	110.7 ± 122.2	0.511
Open conversion	0	1 (1.6%)	0.293	2 (1.3%)	0	0.164
Complications	11 (16.2%)	8 (12.9%)	0.598	19 (12.3%)	22 (14.8%)	0.522
Retrieved lymph nodes	31.5 ± 12.5	30.9 ± 13.2	0.796	35.8 ± 11.5	35.8 ± 12.6	0.699
Hospital stay (day)	6.90 ± 3.42	6.98 ± 2.81	0.875	7.15 ± 3.99	7.21 ± 4.66	0.904

± Values are the standard deviations.

Please cite this article in press as: Park JM, et al., Who may benefit from robotic gastrectomy?: A subgroup analysis of multicenter prospective comparative study data on robotic versus laparoscopic gastrectomy, Eur J Surg Oncol (2016), http://dx.doi.org/10.1016/j.ejso.2016.07.012

Table 2
Comparison of robotic and laparoscopic gastrectomy by the extent of gastric resection.

Characteristic	Total gastrectomy (n = 72)			Partial gastrectomy (n = 362)		
	Robot (n = 42)	Laparoscopy (n = 30)	*P*-value	Robot (n = 181)	Laparoscopy (n = 181)	*P*-value
Age (years)	51.7 ± 12.0	57.1 ± 11.1	0.056	52.6 ± 11.1	55.6 ± 11.1	0.011
Male gender	26 (61.9%)	18 (60.0%)	0.870	105 (58.0%)	108 (59.7%)	0.749
Stage			0.148			0.008
IA	24 (57.1%)	23 (76.7%)		130 (71.8%)	154 (85.1%)	
IB	4 (9.5%)	3 (10.0%)		22 (12.2%)	32 (8.8%)	
II/III	14 (33.3%)	4 (13.3%)		29 (16.0%)	46 (12.7%)	
Obesity			0.783			0.820
BMI ≥ 25	11 (26.2%)	7 (23.3%)		57 (31.5%)	55 (30.4%)	
BMI < 25	31 (73.8%)	23 (76.7%)		124 (68.5%)	126 (69.6%)	
Lymph node dissection			0.355			0.057
D2	20 (47.6%)	11 (36.7%)		90 (49.7%)	72 (39.8%)	
D1 or D1+	22 (52.4%)	19 (63.3%)		91 (50.3%)	109 (60.2%)	
Operative time (min)	276.7 ± 71.4	228.1 ± 76.2	0.007	224.2 ± 63.1	179.6 ± 56.7	<0.001
Blood loss (ml)	139.5 ± 204.5	157.6 ± 199.1	0.709	88.0 ± 98.4	96.7 ± 96.4	0.397
Open conversion	1 (2.4%)	0	0.395	1 (0.6%)	1 (0.6%)	1.000
Complication	11 (26.2%)	5 (16.7%)	0.338	19 (10.5%)	25 (13.8%)	0.335
Retrieved lymph nodes	37.5 ± 11.4	40.7 ± 13.9	0.291	33.3 ± 12.0	32.8 ± 12.1	0.675
Hospital stay (day)	9.26 ± 7.50	6.83 ± 3.21	0.100	6.57 ± 1.95	7.20 ± 4.35	0.076

± Values are the standard deviations.

Table 3
Comparison of robotic and laparoscopic gastrectomy by the extent of lymph node dissection.

Characteristic	D2 LN dissection (n = 193)			D1 or D1+ LN dissection (n = 241)		
	Robot (n = 110)	Laparoscopy (n = 83)	*P*-value	Robot (n = 113)	Laparoscopy (n = 128)	*P*-value
Age (years)	51.9 ± 11.0	54.9 ± 11.0	0.060	53.1 ± 11.5	56.5 ± 11.2	0.021
Male gender	68 (61.8%)	62 (74.7%)	0.059	63 (55.8%)	64 (50.0%)	0.372
Stage			0.037			0.082
IA	66 (60.0%)	64 (77.1%)		88 (77.9%)	113 (88.3%)	
IB	15 (13.6%)	5 (6.0%)		11 (9.7%)	8 (6.3%)	
II/III	29 (26.4%)	14 (16.9%)		14 (12.4%)	7 (5.5%)	
Obesity			0.749			0.651
BMI ≥ 25	26 (23.6%)	18 (21.7%)		42 (37.2%)	44 (34.4%)	
BMI < 25	84 (76.4%)	65 (78.3%)		71 (62.8%)	84 (65.6%)	
Gastric resection			0.356			0.340
Total	20 (18.2%)	11 (13.3%)		22 (19.5%)	19 (14.8%)	
Partial	90 (81.8%)	72 (86.7%)		91 (80.5%)	109 (85.2%)	
Operative time (min)	220.9 ± 68.2	187.8 ± 57.1	<0.001	246.9 ± 65.3	185.7 ± 65.2	<0.001
Blood loss (ml)	98.9 ± 105.7	140.5 ± 143.1	0.021	96.5 ± 144.2	82.6 ± 91.7	0.365
Open conversion	0	0		2 (1.8%)	1 (0.8%)	0.490
Complication	10 (9.1%)	11 (13.3%)	0.548	20 (17.7%)	19 (14.8%)	0.358
Retrieved lymph nodes	37.4 ± 10.4	37.6 ± 12.5	0.917	30.9 ± 12.6	31.5 ± 12.1	0.695
Hospital stay (day)	7.31 ± 4.58	7.10 ± 2.28	0.698	6.85 ± 2.89	7.18 ± 5.08	0.543

± Values are the standard deviations.

only observed in the non-obese patient group that underwent total gastrectomy. Hyun et al.[18] stated that there was no benefit of robotic surgery in obese patients. Moreover, for obese patients, the number of lymph nodes retrieved was smaller in the robotic group than in the laparoscopic group. Because of differences among individual surgeons, the benefits of a robotic procedure may vary according to surgeon preference, experience, or skills, which may explain the different results among these studies. Compared with these previous reports from single institution studies, our study was a subgroup analysis of data from a multicenter prospective study and may provide more reliable results.

In the present study, although a robotic system was not helpful for overcoming the difficulties of laparoscopic surgery for obese patients and total gastrectomy, the benefit of performing robotic gastrectomy was observed in D2 lymph node dissection, but not in D1 or D1+ procedures. Generally, robotic surgery may be beneficial for complicated procedures rather than for simple procedures. For instance, extended pelvic lymph node dissection in prostatectomy,[19] mediastinal lymph node dissection in esophagectomy,[20,21] and total mesorectal excision in lower rectal resection[22] have been reported to more significantly from robotic surgery than from conventional laparoscopy because these procedures are complicated. Similarly, the extended lymph

Please cite this article in press as: Park JM, et al., Who may benefit from robotic gastrectomy?: A subgroup analysis of multicenter prospective comparative study data on robotic versus laparoscopic gastrectomy, Eur J Surg Oncol (2016), http://dx.doi.org/10.1016/j.ejso.2016.07.012

node dissection procedure is the most complicated and challenging part of the gastrectomy procedure. Therefore, the benefit of robotic surgery in gastrectomy was shown in D2 lymph node dissection in this study.

D2 lymph node dissection has been reported to have long-term survival benefits over D1 lymph node dissection in several randomized and non-randomized prospective trials.[23,24] D2 lymph node dissection has become a standard procedure for the curative treatment of gastric cancer, especially for patients with advanced gastric cancer (AGC). However, D2 lymphadenectomy in cases of laparoscopic gastrectomy is a technically demanding procedure for AGC. Therefore, the benefit of robotic gastrectomy in D2 lymphadenectomy is an important factor to consider when choosing the technique for AGC. Our results show that the use of robotic surgery in the treatment of AGC is promising for those who require D2 lymph node dissection for curative treatment.

Although serious complications derived from bleeding or the length of the hospital stay were not related to the amount of intraoperative blood loss, greater blood loss during the surgery can reveal the difficulty of the procedure and may be related to complications not reflected in this data. In addition, although transfusion during surgery was not definitively related with EBL in our study,[14] intraoperative bleeding may be related with perioperative transfusions that may negatively impact oncological outcomes.[25,26] Thus, robotic systems may facilitate better surgical outcomes in D2 gastrectomy.

Nevertheless, morbidity and mortality were similar for both surgical techniques in all subgroups. Both laparoscopic and robotic gastrectomies are comparably safe procedures. Thus, the complication rate and length of hospital stay are also expected to be similar. To clarify the difference in complication rate and length of hospital stay between the two surgical techniques, a randomized controlled study with adequate sample size is necessary.

This study had a few limitations. First, the enrolled patients were not controlled using a randomized method but were matched after enrollment into the robotic arm. Although the patients were matched by the surgeon, sex, and extent of gastric resection, there were significant differences in age, comorbidity, and cancer stage between the robotic and laparoscopic groups. Thus, this discordance could have influenced on our results. Second, some surgeons' early experiences with robotic gastrectomy were included in this data, while all surgeons were highly experienced in laparoscopic gastrectomy. Thus, the experience in surgical technique was not the same between the robotic and laparoscopic groups, which could also have been a confounding factor. Further study with only experienced surgeons may provide better insight. Third, the outcome of the present study was not designed as a primary endpoint, but rather stemmed from secondary analyses of subgroups. In general, a subgroup analysis has the potential to be misleading because of reduced sample size and unbalanced characteristics in each subgroup. However, the clinicopathologic characteristics of the subgroups in this study were similar to those of the overall population, although the statistical power in the subgroups was reduced as the sample size decreased.

Conclusion

Robotic assistance was not helpful in overcoming the difficulty of laparoscopic gastrectomy for obese patients or in cases of total gastrectomy. However, there was significantly less blood loss with robotic gastrectomy for patients undergoing D2 lymph node dissection. Therefore, based on our results, robotic gastrectomy may be recommended for patients undergoing D2 lymph node dissection. Further studies with randomization comparing robotic and laparoscopic gastrectomy in patients undergoing D2 gastrectomy for advanced cancer are necessary.

Conflict of interest

The authors report they have no conflicts of interest or financial ties to disclose.

Acknowledgements

This research was supported by a grant from the National R&D Program for Cancer Control, Ministry of Health & Welfare, Republic of Korea (1020410), and the National Cancer Center, Republic of Korea (Grant No. 1410140-2).

References

1. Kim HH, Hyung WJ, Cho GS, et al. Morbidity and mortality of laparoscopic gastrectomy versus open gastrectomy for gastric cancer: an interim report—a phase III multicenter, prospective, randomized trial (KLASS Trial). *Ann Surg* 2010;**251**:417–20.
2. Kim YW, Baik YH, Yun YH, et al. Improved quality of life outcomes after laparoscopy-assisted distal gastrectomy for early gastric cancer: results of a prospective randomized clinical trial. *Ann Surg* 2008;**248**:721–7.
3. Kitano S, Shiraishi N, Fujii K, et al. A randomized controlled trial comparing open vs laparoscopy-assisted distal gastrectomy for the treatment of early gastric cancer: an interim report. *Surgery* 2002;**131**:S306–11.
4. Kodera Y, Fujiwara M, Ohashi N, et al. Laparoscopic surgery for gastric cancer: a collective review with meta-analysis of randomized trials. *J Am Coll Surg* 2010;**211**:677–86.
5. Woo Y, Hyung WJ, Pak KH, et al. Robotic gastrectomy as an oncologically sound alternative to laparoscopic resections for the treatment of early-stage gastric cancers. *Arch Surg* 2011;**146**:1086–92.
6. Galmiche JP, Hatlebakk J, Attwood S, et al. Laparoscopic antireflux surgery vs esomeprazole treatment for chronic GERD: the LOTUS randomized clinical trial. *JAMA* 2011;**305**:1969–77.
7. Kim MC, Heo GU, Jung GJ. Robotic gastrectomy for gastric cancer: surgical techniques and clinical merits. *Surg Endosc* 2010;**24**:610–5.

Please cite this article in press as: Park JM, et al., Who may benefit from robotic gastrectomy?: A subgroup analysis of multicenter prospective comparative study data on robotic versus laparoscopic gastrectomy, Eur J Surg Oncol (2016), http://dx.doi.org/10.1016/j.ejso.2016.07.012

8. Huang KH, Lan YT, Fang WL, et al. Initial experience of robotic gastrectomy and comparison with open and laparoscopic gastrectomy for gastric cancer. *J Gastrointest Surg* 2012;**16**:1303–10.
9. Uyama I, Kanaya S, Ishida Y, et al. Novel integrated robotic approach for suprapancreatic D2 nodal dissection for treating gastric cancer: technique and initial experience. *World J Surg* 2012;**36**:331–7.
10. Liao GX, Xie GZ, Li R, et al. Meta-analysis of outcomes compared between robotic and laparoscopic gastrectomy for gastric cancer. *Asian Pac J Cancer Prev* 2013;**14**:4871–5.
11. Shen WS, Xi HQ, Chen L, Wei B. A meta-analysis of robotic versus laparoscopic gastrectomy for gastric cancer. *Surg Endosc* 2014;**28**:2795–802.
12. Marano A, Choi YY, Hyung WJ, et al. Robotic versus laparoscopic versus open gastrectomy: a meta-analysis. *J Gastric Cancer* 2013;**13**:136–48.
13. Hyun MH, Lee CH, Kim HJ, Tong Y, Park SS. Systematic review and meta-analysis of robotic surgery compared with conventional laparoscopic and open resections for gastric carcinoma. *Br J Surg* 2013; **100**:1566–78.
14. Kim HI, Han SU, Yang HK, et al. Multicenter prospective comparative study of robotic versus laparoscopic gastrectomy for gastric adenocarcinoma. *Ann Surg* 2016;**263**:103–9.
15. Japanese Gastric Cancer A. Japanese gastric cancer treatment guidelines 2010 (ver. 3). *Gastric Cancer* 2011;**14**:113–23.
16. Lee J, Kim YM, Woo Y, et al. Robotic distal subtotal gastrectomy with D2 lymphadenectomy for gastric cancer patients with high body mass index: comparison with conventional laparoscopic distal subtotal gastrectomy with D2 lymphadenectomy. *Surg Endosc* 2015;**29**:3251–60.
17. Park JY, Ryu KW, Reim D, et al. Robot-assisted gastrectomy for early gastric cancer: is it beneficial in viscerally obese patients compared to laparoscopic gastrectomy? *World J Surg* 2015;**39**:1789–97.
18. Hyun MH, Lee CH, Kwon YJ, et al. Robot versus laparoscopic gastrectomy for cancer by an experienced surgeon: comparisons of surgery, complications, and surgical stress. *Ann Surg Oncol* 2013;**20**: 1258–65.
19. Heidenreich A, Varga Z, Von Knobloch R. Extended pelvic lymphadenectomy in patients undergoing radical prostatectomy: high incidence of lymph node metastasis. *J Urol* 2002;**167**:1681–6.
20. Mori K, Yamagata Y, Wada I, et al. Robotic-assisted totally transhiatal lymphadenectomy in the middle mediastinum for esophageal cancer. *J Robot Surg* 2013;**7**:385–7.
21. Ruurda JP, van der Sluis PC, van der Horst S, van Hilllegersberg R. Robot-assisted minimally invasive esophagectomy for esophageal cancer: a systematic review. *J Surg Oncol* 2015;**112**:257–65.
22. Ghezzi TL, Luca F, Valvo M, et al. Robotic versus open total mesorectal excision for rectal cancer: comparative study of short and long-term outcomes. *Eur J Surg Oncol* 2014;**40**:1072–9.
23. Songun I, Putter H, Kranenbarg EM, Sasako M, van de Velde CJ. Surgical treatment of gastric cancer: 15-year follow-up results of the randomised nationwide Dutch D1D2 trial. *Lancet Oncol* 2010;**11**:439–49.
24. Degiuli M, Sasako M, Ponti A, Calvo F. Survival results of a multicentre phase II study to evaluate D2 gastrectomy for gastric cancer. *Br J Cancer* 2004;**90**:1727–32.
25. Rausei S, Ruspi L, Galli F, et al. Peri-operative blood transfusion in gastric cancer surgery: prognostic or confounding factor? *Int J Surg* 2013;**11**(Suppl. 1):S100–3.
26. Kim SH, Lee SI, Noh SM. Prognostic significance of preoperative blood transfusion in stomach cancer. *J Gastric Cancer* 2010;**10**:196–205.

Please cite this article in press as: Park JM, et al., Who may benefit from robotic gastrectomy?: A subgroup analysis of multicenter prospective comparative study data on robotic versus laparoscopic gastrectomy, Eur J Surg Oncol (2016), http://dx.doi.org/10.1016/j.ejso.2016.07.012