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The effect of preoperative nutritional intervention for adult spinal deformity patients

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Original Article

Title: The effect of preoperative nutritional intervention for adult spinal deformity patients

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IRB approval: The study protocol was approved by the Institutional Review Board of the Hamamatsu University School of Medicine, Shizuoka, Japan (IRB No. 18-179).

Abstract

Study Design: A prospective nutritional intervention study for adult spinal deformity (ASD) patients.

Objective: To investigate how a nutritional intervention affects the incidence of postoperative medical complications and the nutritional status.

Summary of Background Data: The medical complication rate in ASD surgery is very high, and one risk factor is malnutrition. Nutritional intervention may improve the patient's nutritional status and reduce risk, but this is unexplored regarding ASD surgery.

Methods: Malnourished patients (i.e., a Prognostic Nutritional Index (PNI) score of <50) scheduled for surgery after November 2018 (Group I) received nutritional intervention consisting of nutritional guidance and supplements on the surgery day. The medical complication rates between Group I and Group NI (malnourished patients who underwent surgery between January 2014 and October 2018; historical controls) were evaluated. The nutritional status courses of Group I and Group NI2 (patients who did not participate in nutritional intervention after November 2018) were assessed.

Results: Group I had 24 patients in (mean age, 70 years), and Group NI had 69 patients (mean age, 68 years). The mean intervention duration was 41 days. The preoperative PNI score did not differ between the groups, but there was a significant difference in medical complications incidences

(Group I: 25 %; Group NI: 53.6 %; P=0.015). The nutritional status significantly deteriorated in Group I (PNI: 47 to 45; P=0.011) and Group NI2 (61 patients; mean age, 68 years; PNI: 52 to 48; P = 0.000), but the PNI changes were significantly smaller in Group I (ΔPNI: Group I: −1.9, Group NI 2: −3.5; P=0.027).

Conclusion: Nutritional intervention with guidance and supplements reduced postoperative medical complications in malnourished patients. The nutritional status of ASD patients requiring surgery also naturally worsened, suggesting that ASD may contribute to malnutrition. Nutritional intervention may reduce the nutritional status deterioration.

Key Words: Adult spinal deformity; Nutritional intervention; Medical complications; Adverse event; Nutritional status; Prognostic nutritional index; Malnutrition; Controlling nutrition status; Enhanced Recovery After Surgery protocol; autologous blood transfusion; Postoperative complications; Preoperative intervention

Level of Evidence: 3

Introduction

Adult spinal deformity (ASD) surgery is highly invasive. A database study by Worley et al. evaluated 11982 ASD patients and reported a 50.8% incidence of medical complications.[1] Further, Oe et al. reported that medical complications were related to a lower nutritional status.[2] Their study used a nutritional assessment method called the Prognostic Nutritional Index (PNI) and found a significant difference in the incidence of medical complications between malnourished and non-malnourished patients (49.2% vs. 22.8%). Based on these results, they recommended nutritional intervention for preoperatively malnourished ASD patients.

The Enhanced Recovery After Surgery (ERAS) protocol is widespread in the gastrointestinal surgery field, with established associations with accelerated patient recovery, shorter hospital stays, and fewer complications.[3, 4] The ERAS concept was proposed by Kehlet et al. in 1997 and is an evidence-based approach to optimal preoperative, intraoperative, and postoperative care.[5] For example, one ERAS protocol advises cessation of smoking and drinking more than four weeks before surgery, which reduces serious adverse events after surgery.[6] Preoperative nutritional intervention is another ERAS protocol and has been a current research topic in the gastrointestinal surgery field.[7-11] Similar studies are also being conducted in the geriatrics field.[12-16] These studies demonstrated that nutritional intervention effectively increased ambulatory function,[7] decreased complications,[8, 9, 13] alleviated weight gain or weight loss,[9, 16] shortened the hospital stay,[8, 14] improved self-related health,[16] improved cost-effectiveness,[8, 9] and reduced readmission rates.[8, 13] Conversely, other studies report ineffectiveness or a lack of evidence.[10-12, 15] However, there have been no reports on nutritional interventions regarding spinal diseases, especially ASD. Hasegawa et al. reported that 90 of 230 patients (39 %) who underwent ASD surgery had gastroesophageal reflux disease (GERD)[17] due to abdominal compression from kyphosis or kyphoscoliosis. Therefore, the nutritional status of ASD patients may deteriorate due to decreased physical activity because of back pain and appetite loss from GERD. However, there have been no reports investigating the natural nutritional status course in patients with ASD. This study conducted a prospective nutritional intervention study in malnourished patients scheduled for ASD surgery to investigate the incidence of postoperative medical complications and the natural nutritional status history.

Material and Methods

Ethical Considerations

This prospective nutritional intervention study was initiated in November 2018 after the approval of the Ethics Committee of our University Hospital (IRB no. 18-179).

Patients

ASD patients with at least one of the following on whole-spine standing radiographs were included: Cobb angle ≥20° in the coronal plane, sagittal vertical axis ≥5 cm, pelvic tilt ≥25°, or thoracic kyphosis ≥60°. Further, included patients were aged ≥40 years, had ≥4 fused vertebral segments, and provided informed consent before surgery. Those with neuromuscular disease, malignancy, infection, and congenital or syndromic scoliosis were excluded.

Nutritional Status Assessment

PNI was used to assess the patient's nutritional status and was calculated as follows[18]:

$$\text{PNI: } 10 \times \text{serum albumin (g/dL)} + 0.005 \times \text{total lymphocyte count (/µL)}$$

Malnutrition was defined as a PNI of <50 based on the report by Oe et al.[2, 19]

Intervention Group (Group I)

The study was conducted between November 2018 and November 2020. The laboratory data (LD) of patients scheduled for surgery were checked for before admission (usually one to two months before surgery), and if their PNI was less than 50, they were asked to participate in the study. Upon agreement, dietitians were contacted on behalf of the patient. The dietitian provided nutritional guidance and instructed them to consume a nutritional supplement drink (Meiji, Maybalance Mini: Energy 200 kcal, Protein 7.5 g, Lipid 5.6 g, and Carbohydrate 31.7 g) three times per day. The dietitians surveyed their food intake and provided counseling once per month. On the day of admission (usually one day before surgery), the LD were rechecked, and the patients were asked to self-report on a scale of 0 % to 100 % if they were able to drink the nutritional supplement per the dietitian's instructions.

No Intervention Group 1 (Group NI)

Patients with a PNI of <50 who underwent surgery from January 2014 to October 2018 were included as historical controls. Group NI was compared with Group I to investigate differences in the LD on the admission day and the incidence of complications among malnourished patients (Study 1).

No Intervention Group 2 (Group NI2)

Patients who underwent surgery between November 2018 and November 2020 and had a PNI of ≥50 or who declined nutritional intervention were included. Group NI2 was compared with Group I to identify changes in the LD and nutritional status due to the nutritional intervention (Study 2).

Intervention Group 2 (Group I2) and No intervention Group 3 (Group NI3)

Groups I2 and NI3 were patients in Groups I and NI2, respectively, who did not undergo an autotransfusion. This comparison examined changes in LD and the nutritional status with and without nutritional intervention, excluding the effects of autotransfusions (Study 3).

Measured Data

The measured data were as follows: age, sex, body mass index (BMI), alcohol habit, smoking habit, the number of nutritional intervention days, the number of fused vertebrae, osteotomy (Schwab classification Grade 4 or 5),[20] comorbidities, the American Society of Anesthesiologists (ASA) physical status, Charlson comorbidity index (CCI), LD (i.e. serum albumin [g/dL], total cholesterol [TC; mg/dL], hemoglobin [Hb; g/dL], total lymphocyte count [TLC; /µL], and so on), PNI, controlling nutrition status (CONUT),[21] the operative time, the estimated blood loss, days to discharge, discharge rate to home, and medical complications after the surgery (during admission; normally three weeks). Surgical site infection (SSI) and death were evaluated for six months after the surgery. LD were evaluated before admission (normally one to two months before surgery) and on the admission day (normally one day before surgery). The CONUT was calculated as follows: albumin (≥3.2: 0 points, 3.00-3.49: 2, 2.50-2.99: 4, <2.50: 6), TC (≥180: 0 points, 140-179: 1, 100-139: 2, <100: 3), and TLC (≥1600: 0 points, 1200-1599; 1, 800-1199: 2, <800: 3). Total CONUT scores (albumin + TC+TLC) from 0-1 were classified as normal, 2-4 were mildly malnourished, 5-8 were moderately malnourished, and 9-12 points were severely malnourished.

Statistical Analyses

Statistical analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $P < 0.05$. Continuous variables are presented as means ± standard deviations. Categorical variables were evaluated using the chi-square test or Fisher's exact test. A paired t-test was used to assess laboratory data and nutritional status changes between before admission and the admission day. Each group was compared using an independent t-test.

Results

Patients Characteristics (Study 1)

In total, 108 patients underwent ASD surgery between November 2018 and November 2020 (Figure 1). Of these, 40 patients had a PNI of <50, and 24 patients agreed to participate in study Group I. There were 235 patients who underwent surgery between January 2014 and October 2018. Of these, 163 were excluded due to a PNI of ≥50, 2 patients were <40 years of age, and 1 had spinal tuberculosis; 69 patients were assigned to Group NI. Table 1 presents the patient characteristics. In Group I, the mean nutritional intervention duration was 40.9 days, and the mean achievement rate for the drinking nutritional supplements was 69.6 %. Age, sex, BMI, the number of fused vertebrae, and Grade 4 or 5 osteotomy did not differ between the groups. ASA was significantly higher in Group I than Group NI (Group I: 2.2 %; Group NI: 1.7 %; P=0.004), but individual comorbidities, including CCI did not differ.

Before-admission LD and Post-operative Complications (Study 1)

As shown in Table 2, regarding LD, only TLC significantly differed between Group I and Group NI (Group I: 1454.7/μL; Group NI: 1158.7/μL; P=0.001). Regarding nutritional status, the PNI did not differ (P = 0.346), but the CONUT score was significantly worse in Group NI (2.0: 1.4; P=0.021). The operative time did not differ between the groups, but the blood loss amount was significantly higher in the Group NI (915.3 mL; 1362.6 mL, P=0.014) as was the number of patients with medical complications (6 cases [25%]; 37 cases [53.6 %], P=0.015). Table 3 presents the complication details. In both groups, the most common complication was delirium (3 [12.5 %]; 16 [23.2 %]). The second most common complication was SSI in Group I (3 cases, 12.5 %) and urinary tract infection and ileus (4 cases each) in Group NI. One patient in the Group NI developed delirium during hospitalization and died within six months after surgery.

Patients Characteristics (Study 2)

Group NI2 enrolled 61 of 108 patients who underwent ASD surgery between November 2018 and November 2020, including 45 patients with a PNI score of ≥50 (40 patients with scores <50 were excluded) and aged ≥40 years (23 patients <40 years were excluded); 16 patients had a PNI <50 but declined to participate in this study (Figure 1). Age, sex, and BMI did not differ between Group I and Group NI2 (Table 4). The PNI (46.9; 51.9; P <0.001) and CONUT scores (1.4; 0.7; P=0.013), indicating the nutritional status, were significantly worse in Group I. The number of autotransfusions did not differ between Group I and Group NI2. ASA did not differ between the groups, but CCI was significantly higher in Group I (1.8; 0.7, P=0.017). The numbers of cases with medical complications did not differ between the two groups, but the home discharge rate was significantly worse in Group I (54.2 %; 77.0 %; P=0.037).

LD and Nutritional Status Changes from Before Admission to the Admission Day (Study 2)

The blood sampling duration from before admission to the admission day was 56.2 ± 24.0 days in Group I and 57.6 ± 28.1 days in Group NI2 (P=0.835). Figure 2 illustrates the changes in LD and nutritional status from before admission to the admission day. In both groups, the TLC (Group I: P=0.009, Group NI2: P=0.000), TC (Group I: P=0.006, Group NI2: P=0.006), the Hb (Group I: P=0.007, Group NI2: P=0.000), the PNI (Group I: P=0.011, Group NI2: P = 0.000), and CONUT (Group I: P=0.02, Group NI2: P=0.000) significantly deteriorated by admission day. The prealbumin level significantly decreased in Group NI2 (P=0.000) but did not change in Group I (P=0.740). The amount of TLC, the PNI score, and prealbumin deterioration was significantly smaller in Group I than Group NI2 (ΔTLC: Group I: –192.2 ± 297.9, Group NI2: –456.6 ± 474.3, P=0.023; ΔPNI: –1.9 ± 2.5, Group NI2: –3.5 ± 3.4, P = 0.027; Δprealbumin: Group I: 0.3 ± 4.4, Group NI2: –1.6 ± 3.0, P=0.031).

Patients Characteristics (Study 3)

The 11 patients in Group I who did not undergo autologous blood transfusion were placed in Group I2, and the 30 patients in Group NI2 who did not undergo autologous blood transfusion were placed in Group NI3. As shown in Table 5, there were no significant differences in age, sex, and BMI. The PNI score was significantly worse in Group I2 than Group NI3 (46.4; 50.7, P=0.004), but the CONUT score and medical complication incidences did not differ.

LD and Nutritional Status Changes from Before Admission to the Admission Day (Study 3)

The blood sampling duration from before admission to the admission day was 56.4 ± 29.8 days in Group I2 and 47.9 ± 18.0 days in Group NI2 (P=0.254). Figure 3 illustrates the nutritional status changes. In Group I2, only the Hb (P=0.042) and the CONUT (P=0.040) significantly deteriorated. As in Study 2, prealbumin in Group I2 did not deteriorate (P=0.677). In contrast, in the NI3 group, albumin (P=0.018), TLC (P=0.000), the Hb (P=0.040), the PNI (P=0.000), the CONUT (P=0.000), and the prealbumin level (P=0.030) significantly deteriorated. The amounts of change in each LD or nutritional status did not differ between the two groups.

Discussion

Although several have reported on the effects of nutritional intervention, no study has presented nutritional status changes using quantitative assessment methods, such as blood sampling data. This study is the first to report the effects of nutritional intervention and the nutritional status change before surgery in ASD patients.

Study 1 examined the effect of nutritional intervention in malnourished patients and found that the incidence of postoperative medical complications was significantly lower in Group I than in Group NI. As shown in previous studies, nutritional intervention may reduce the incidence of postoperative complications.[8, 9, 13, 22] The European Society for Clinical Nutrition and Metabolism guideline recommends preoperative nutritional intervention for seven to ten days if the patients have at least one of the following: weight loss >10 to 15 % within six months, BMI <18.5 kg/m^2, a subjective global assessment grade of C or a nutritional risk screening score >5, and preoperative serum albumin <3.0g/L.[23] In our study, the PNI did not differ between the two groups, but the CONUT was significantly worse in Group NI, which may have affected the incidence of medical complications. Furthermore, although surgical invasion, such as the number of fused vertebrae or osteotomy, did not differ, bleeding significantly increased in Group NI. It might affect due to advances in medical technology and inexperience in surgical techniques, as the control group was a historical control. Therefore, the surgical invasion could have influenced the occurrence of complications in the historical control group.

Study 2 compared cases after November 2018, when the nutrition intervention study began. The main purpose of Study 2 was to investigate whether nutritional intervention improved the nutritional status and LD. Both Group I and Group NI2 had a significant decrease in the nutritional status over the approximately two months between the first blood sampling and the admission day. The nutritional status of patients with severe ASD scheduled for surgery may deteriorate due to stress, loss of appetite, movement disorders from GERD[17], and severe pain. Thus, ASD itself may contribute to malnutrition. Investigating the LD and nutritional status trends in patients other than those with ASD is necessary for confirmation. In contrast, TLC, PNI, and prealbumin levels were significantly better in Group I than Group NI2. Nutritional intervention promoted an upward trend, although it was not significant for prealbumin. Furthermore, the incidence of medical complications did not differ between the two groups. These results suggest that nutritional intervention could reduce the incidence of postoperative complications in malnourished patients to the same level as in well-nourished patients.

Study 3 was conducted in addition to Study 2 to exclude the effect of autologous blood sampling, which may cause the nutritional status to worsen in the two months before the day of admission. The results of Study 3 were similar to Study 2, suggesting that the nutritional status naturally worsens in patients with severe ASD waiting for surgery regardless of autologous blood presence. The effects of the nutritional intervention were also similar but insignificant, suggesting that they may prevent the decline of TLC, PNI, and prealbumin levels.

This study demonstrated that nutritional intervention possibly reduces the deterioration of the nutritional status, but it did not increase the PNI or CONUT. However, the effect of nutritional intervention alone may be limited. Therefore, pre-habilitation with exercise therapy may be a necessary. Preoperative exercise therapy has been reported to reduce postoperative complications and hospital stays in patients undergoing cardiac and abdominal surgeries.[24, 25] Gillis et al. also reported that the key to pre-habilitation is to combine exercise therapy with nutritional therapy.[26] Pre-habilitation has also been shown useful in improving physical function,[27-29] but it takes four to five weeks for exercise therapy to be effective.[29, 30] ASD surgery is highly invasiveness with a high complication rate. Therefore, it is important to perform pre-habilitation, which combines nutritional therapy and exercise therapy, at least four to five weeks before surgery.

This study had several limitations. One is the small number of cases, which may have affected the statistical analyses. Second, the control group in Study 1 was a historical control, which may affect the assessment of complication rates. For future studies, malnourished patients should be randomly assigned to the intervention or non-intervention groups.

In conclusion, nutritional intervention with nutritional guidance and supplements reduced postoperative medical complications in malnourished patients. ASD patients requiring surgery had a naturally worsening nutritional status, implying that ASD may cause malnutrition. Nutritional intervention may slow the nutritional status deterioration, especially regarding the TLC, the PNI, and prealbumin level. Nutritional intervention should be performed preoperatively in malnourished patients with a PNI score of <50 to prevent postoperative complications.

References

1. Worley N, Marascalchi B, Jalai CM, Yang S, et al. Predictors of inpatient morbidity and mortality in adult spinal deformity surgery. *Eur Spine J* Mar 2016;25(3):819–27. doi:10.1007/s00586-015-4104-x.

2. Oe S, Yamato Y, Hasegawa T, Yoshida G, et al. Association between a prognostic nutritional index less than 50 and the risk of medical complications after adult spinal deformity surgery. *J Neurosurg Spine* Mar 27 2020;33(2):219–24. doi:10.3171/2020.1.SPINE191410.

3. Li C, Ferri LE, Mulder DS, Ncuti A, et al. An enhanced recovery pathway decreases duration of stay after esophagectomy. *Surgery* Oct 2012;152(4):606–14; discussion 614–6. doi:10.1016/j.surg.2012.07.021.

4. Lee L, Li C, Robert N, Latimer E, et al. Economic impact of an enhanced recovery pathway for oesophagectomy. *Br J Surg* Sep 2013;100(10):1326–34. doi:10.1002/bjs.9224.

5. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth* May 1997;78(5):606–17. doi:10.1093/bja/78.5.606.

6. Tønnesen H, Nielsen PR, Lauritzen JB, Møller AM. Smoking and alcohol intervention before surgery: evidence for best practice. *Br J Anaesth* Mar 2009;102(3):297–306. doi:10.1093/bja/aen401.

7. Gillis C, Loiselle SE, Fiore JF, Jr., Awasthi R, et al. Prehabilitation with whey protein

supplementation on perioperative functional exercise capacity in patients undergoing colorectal resection for cancer: A pilot double-blinded randomized placebo-controlled trial. *J Acad Nutr Diet* May 2016;116(5):802–12. doi:10.1016/j.jand.2015.06.007.

8. Maňásek V, Bezděk K, Foltys A, Klos K et al. The impact of high protein nutritional support on clinical outcomes and treatment costs of patients with colorectal cancer. *Klin Onkol* 2016;29(5):351–7.

9. Smedley F, Bowling T, James M, Stokes E, et al. Randomized clinical trial of the effects of preoperative and postoperative oral nutritional supplements on clinical course and cost of care. *Br J Surg* Aug 2004;91(8):983–90. doi:10.1002/bjs.4578.

10. MacFie J, Woodcock NP, Palmer MD, Walker A et al. Oral dietary supplements in pre- and postoperative surgical patients: a prospective and randomized clinical trial. *Nutrition* Sep 2000;16(9):723–8. doi:10.1016/s0899-9007(00)00377-4.

11. Burden ST, Hill J, Shaffer JL, Campbell M et al. An unblinded randomised controlled trial of preoperative oral supplements in colorectal cancer patients. *J Hum Nutr Diet* Oct 2011;24(5):441–8. doi:10.1111/j.1365-277X.2011.01188.x.

12. Milne AC, Potter J, Vivanti A, Avenell A. Protein and energy supplementation in elderly people at risk from malnutrition. *Cochrane Database Syst Rev* Apr 15 2009;2(2):CD003288. doi:10.1002/14651858.CD003288.pub3.

13. Cawood AL, Elia M, Stratton RJ. Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. *Ageing Res Rev* Apr 2012;11(2):278–96. doi:10.1016/j.arr.2011.12.008.

14. Stratton RJ, Hébuterne X, Elia M. A systematic review and meta-analysis of the impact of oral nutritional supplements on hospital readmissions. *Ageing Res Rev* Sep 2013;12(4):884–97. doi:10.1016/j.arr.2013.07.002.

15. Collins J, Porter J. The effect of interventions to prevent and treat malnutrition in patients admitted for rehabilitation: a systematic review with meta-analysis. *J Hum Nutr Diet* Feb 2015;28(1):1–15. doi:10.1111/jhn.12230.

16. Terp R, Jacobsen KO, Kannegaard P, Larsen AM et al. A nutritional intervention program improves the nutritional status of geriatric patients at nutritional risk-a randomized controlled trial. *Clin Rehabil* Jul 2018;32(7):930–41. doi:10.1177/0269215518765912.

17. Hasegawa T, Ushirozako H, Yamato Y, Togawa D, et al. Impact of adult spinal deformity corrective surgery in patients with the symptoms of gastroesophageal reflux disease: a 5-year follow-up report. *Eur Spine J* Apr 2020;29(4):860–9. doi:10.1007/s00586-020-06300-2.

18. Onodera T, Goseki N, Kosaki G. [Prognostic nutritional index in gastrointestinal surgery of malnourished cancer patients]. *Nihon geka gakkai zasshi* Sep 1984;85(9):1001–5.

19. Oe S, Togawa D, Yamato Y, Hasegawa T, et al. Preoperative age and prognostic

nutritional index are useful factors for evaluating postoperative delirium among patients with adult spinal deformity. *Spine* Apr 1 2019;44(7):472–8. doi:10.1097/BRS.0000000000002872.

20. Schwab F, Blondel B, Chay E, Demakakos J, et al. The comprehensive anatomical spinal osteotomy classification. *Neurosurgery* Mar 2015;76;Suppl 1:S33–41; discussion S41. doi:10.1227/01.neu.0000462076.73701.09.

21. Ignacio de Ulíbarri J, González-Madroño A, de Villar NG, González P, et al. CONUT: a tool for controlling nutritional status. First validation in a hospital population. *Nutr hosp* Jan–Feb 2005;20(1):38–45.

22. Fukuda Y, Yamamoto K, Hirao M, Nishikawa K, et al. Prevalence of malnutrition among gastric cancer patients undergoing gastrectomy and optimal preoperative nutritional support for preventing surgical site infections. *Ann Surg Oncol* Dec 2015;22;Suppl 3:S778–85. doi:10.1245/s10434-015-4820-9.

23. Weimann A, Braga M, Carli F, Higashiguchi T, et al. ESPEN guideline. ESPEN guideline: Clinical nutrition in surgery. *Clin Nutr* Jun 2017;36(3):623–50. doi:10.1016/j.clnu.2017.02.013.

24. Santa Mina D, Clarke H, Ritvo P, Leung YW, et al. Effect of total-body prehabilitation on postoperative outcomes: a systematic review and meta-analysis. *Physiotherapy* Sep 2014;100(3):196–207. doi:10.1016/j.physio.2013.08.008.

25. Valkenet K, van de Port IG, Dronkers JJ, de Vries WR et al. The effects of preoperative exercise therapy on postoperative outcome: a systematic review. *Clin Rehabil* Feb 2011;25(2):99–111. doi:10.1177/0269215510380830.

26. Gillis C, Buhler K, Bresee L, Carli F, et al. Effects of nutritional prehabilitation, with and without exercise, on outcomes of patients who undergo colorectal surgery: A systematic review and meta-analysis. *Gastroenterology* Aug 2018;155(2):391–410.e4. doi:10.1053/j.gastro.2018.05.012.

27. Minnella EM, Awasthi R, Loiselle SE, Agnihotram RV et al. Effect of exercise and nutrition prehabilitation on functional capacity in esophagogastric cancer surgery: A randomized clinical trial. *JAMA Surg* Dec 1 2018;153(12):1081–9. doi:10.1001/jamasurg.2018.1645.

28. Barakat HM, Shahin Y, Khan JA, McCollum PT et al. Preoperative supervised exercise improves outcomes after elective abdominal aortic aneurysm repair: A randomized controlled trial. *Ann Surg* Jul 2016;264(1):47–53. doi:10.1097/SLA.0000000000001609.

29. Dunne DF, Jack S, Jones RP, Jones L, et al. Randomized clinical trial of prehabilitation before planned liver resection. *Br J Surg* Apr 2016;103(5):504–12. doi:10.1002/bjs.10096.

30. Chen BP, Awasthi R, Sweet SN, Minnella EM, et al. Four-week prehabilitation program is sufficient to modify exercise behaviors and improve preoperative functional walking capacity in patients with colorectal cancer. *Support Care Cancer* Jan 2017;25(1):33–40.

doi:10.1007/s00520-016-3379-8.

Table 1. The characteristics of patients with PNI less than 50			
Group	I (n=24)	NI (n=69)	P
Age	70.3±7.2	68.1±8.8	0.294
Female	20(83.3%)	52(75.4%)	0.421
BMI (kg/m2)	23.2±3.3	22.2±3.2	0.218
Alcohol (Yes)	3 (12.5%)	7 (10.1%)	0.504
Smoking (Yes)	2 (8.3%)	0	0.065
The days of nutritional intervention	40.9±23.2	-	
Achievement rate for nutritional supplements(%)	69.6±38.5	-	
No of fused vertebrae	10.0±2.9	9.7±2.5	0.870
Osteotomy (Grade 4 or 5)	6 (25%)	12 (17.4%)	0.297
Cardiovascular disorder	3 (12.5%)	5 (7.2%)	0.339
Diabetes	4 (16.7%)	5 (7.2%)	0.270
Respiratory disorder	3 (12.5%)	5 (7.2%)	0.339
History of malignant disease	4 (16.7%)	12 (17.4%)	0.604
Liver disease	2 (8.3%)	3 (4.3%)	0.385
Collagen disease	6 (25%)	8 (11.6%)	0.108
Digestive disease	2 (8.3%)	9 (13.0%)	0.420
History of stroke	4 (16.7%)	7 (10.1%)	0.302
Psychogenic disorder	1 (4.2%)	8 (11.6%)	0.268
Chronic kidney disease	2 (8.3%)	3 (4.3%)	0.385
Osteoporosis	8 (33.3%)	15 (21.7%)	0.257
ASA physical status	2.2±0.6	1.7±0.7	0.004*

CCI	1.8±2.1	1.0±1.3	0.097

*: P<0.01, I: nutritional intervention, NI: no nutritional intervention, BMI; body mass index, ASA; American Society of Anesthesiologists, CCI; Charson Comorbidity Index

Table 2. Preoperative laboratory data and postoperative outcome among patients with PNI less than 50			
Group	I (n=24)	NI (n=69)	P
Sodium (mEq/l)	141.6±1.8	141.6±3.4	0.980
Potassium (mEq/l)	4.1±0.4	4.3±0.4	0.066
Chloride (mEq/l)	104.5±2.9	104.9±3.4	0.605
Blood urea nitrogen (mg/dl)	20.9±11.2	19.1±8.9	0.413
Creatinine (mg/dl)	0.83±0.62	0.92±1.2	0.721
Aspartate aminotransferase (U/l)	21.6±5.4	23.8±8.6	0.235
Alanine transaminase (U/l)	16.2±9.1	18.3±9.9	0.356
C-reactive protein (mg/dl)	0.35±0.54	0.21±0.28	0.232
Albumin (g/dl)	4.0±0.3	4.1±0.2	0.250
Total cholesterol (mg/dl)	196.1±32.4	194.9±32.5	0.871
Hemoglobin (g/dl)	13.0±1.3	12.5±1.4	0.138
Total lymphocyte count (/μl)	1454.7±419.1	1158.7±323.9	0.001**
PNI	46.9±3.1	46.3±2.5	0.346
CONUT	1.4±1.3	2.0±1.1	0.021*
Operative time (minutes)	442.9±127.9	445.8±76.6	0.917
Estimated blood loss (ml)	915.3±662.4	1362.6±777.9	0.014*
Delirium	3 (12.5%)	16 (23.2%)	0.208
SSI	3 (12.5%)	1 (1.4%)	0.051
No. of patients with medical complications	6 (25%)	37 (53.6%)	0.015*
Days to discharge	22.0±15.9	27.1±11.7	0.099

Discharge to home	13 (54.2%)	45 (65.2%)	0.336
*: P<0.05, **; P<0.01, I: nutritional intervention, NI: no nutritional intervention, PNI; Prognostic Nutritional Index, CONUT; Controlling Nutrition Status, SSI; surgical site infection			

Table 3. The perioperative medical complications

Groups		I (n=24)	NI (n=69)
No. of patients		6 (25%)	37 (53.6%)
Delirium and	-	2	9
	SSI	1	0
	UTI	0	2
	Hyponatremia	0	1
	DVT & PE	0	1
	Decubitus	0	1
	Death	0	1
	Ileus	0	1
SSI		2	1
Ileus and	-	0	3
	Acute heart failure & Atelectasis	0	1
	DVT & PE	0	1
Urinary tract infection		1	2
DVT and	PE	0	1

	Pneumoniae	0	1
Arrythmia and	-	0	1
	Decubitus & Cystitis	0	1
Anaphylactic shock due to blood transfusion		0	1
Decubitus		0	1
Cystitis		0	1
Wound separation		0	1
Influenza infection		0	1
Duodenal ulcer		0	1
Hyponatremia		0	1
Pseudomembranous enteritis		0	1
Benign Paroxysmal Positional Vertigo		0	1
I: nutritional intervention, NI: no nutritional intervention, SSI; surgical site infection, UTI; urinary tract infection, DVT; deep venous thrombosis, PE; pulmonary embolism			

Table 4. The comparison between nutritional intervention group and no nutritional intervention group since November 2018 (Study 2)

Group	I (n=24)	NI2 (n=61)	P
Age	70.3±7.2	68.0±9.4	0.287
Female	20(83.3%)	54(88.5%)	0.375
BMI (kg/m2)	23.2±3.3	23.3±3.5	0.903
Alcohol (Yes)	3 (12.5%)	8(13.1%)	0.625

Smoking (Yes)		2 (8.3%)	4 (6.6%)	0.547
PNI		46.9±3.1	51.9±4.3	0.000**
CONUT		1.4±1.3	0.7±0.9	0.013*
Autotransfusion	Yes	13 (54.2%)	31 (50.8%)	0.781
	Total amount (ml)	800±0	741.9±138.5	0.026*
No of fused vertebrae		10.0±2.9	10.4±3.7	0.705
ASA physical status		2.2±0.6	2.0±0.5	0.122
CCI		1.8±2.1	0.7±1.0	0.017*
Operative time (minutes)		442.9±127.9	431.9±122.5	0.714
Estimated blood loss (ml)		915.3±662.4	925.7±585.8	0.946
Delirium		3 (12.5%)	6 (9.8%)	0.296
SSI		3 (12.5%)	3 (4.9%)	0.217
No. of patients with medical complications		6 (25%)	19 (31.1%)	0.576
Days to discharge		22.0±15.9	17.9±5.7	0.225
Discharge to home		13 (54.2%)	47 (77.0%)	0.037*

*: P<0.05, **; P<0.01, I: nutritional intervention, NI2: no nutritional intervention since November 2018, BMI; body mass index, PNI; Prognostic nutritional index, CONUT; Controlling nutrition status, ASA; American Society of Anesthesiologists, CCI; Charson Comorbidity Index, SSI; surgical site infection

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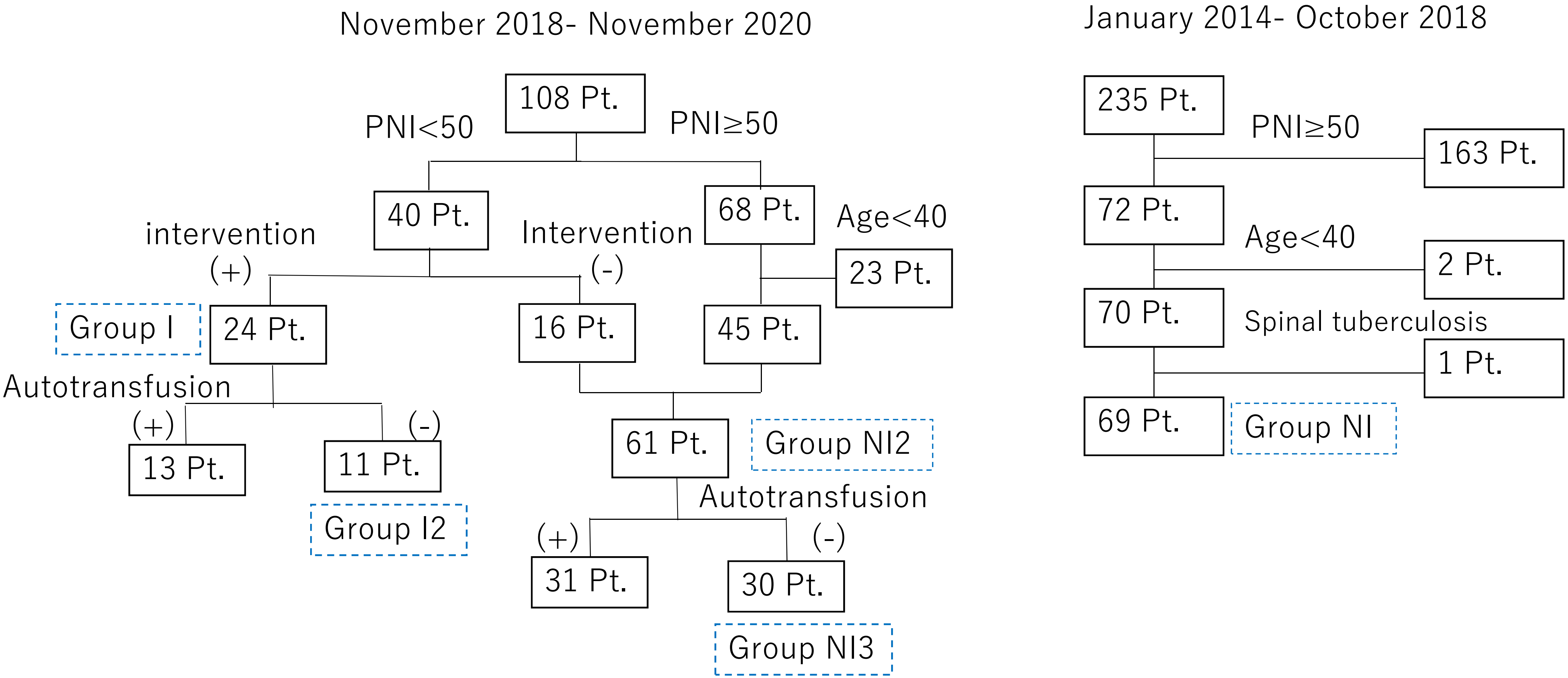
Table 5. The comparison between nutritional intervention group and no nutritional intervention group without autotransfusion since November 2018 (study 3)			
Group	I2 (n=11)	NI3 (n=30)	P
Age	72.9±7.3	70.6±9.4	0.460
Female	8 (72.7%)	26 (86.7%)	0.270
BMI (kg/m2)	23.5±4.1	23.3±3.7	0.908
Alcohol (Yes)	3 (27.3%)	1 (3.3%)	0.052
Smoking (Yes)	1 (9.1%)	2 (6.7%)	0.619
PNI	46.4±3.8	50.7±4.1	0.004**
CONUT	1.6±1.7	0.9±0.9	0.190
No of fused vertebrae	9.8±2.4	10.1±4.2	0.817
ASA physical status	2.2±0.6	2.1±0.5	0.551
CCI	1.7±2.3	0.9±1.0	0.133
Operative time (minutes)	412.5±114.4	431.9±123.3	0.651
Estimated blood loss (ml)	942.9±789.0	932.1±583.0	0.962
Delirium	3 (27.3%)	4 (13.3%)	0.270
SSI	2 (18.2%)	1 (3.3%)	0.170
No. of patients with medical complications	4 (36.4%)	13 (43.3%)	0.487
Days to discharge	28.5±21.8	17.6±6.2	0.132
Discharge to home	6 (54.5%)	21 (70.0%)	0.286

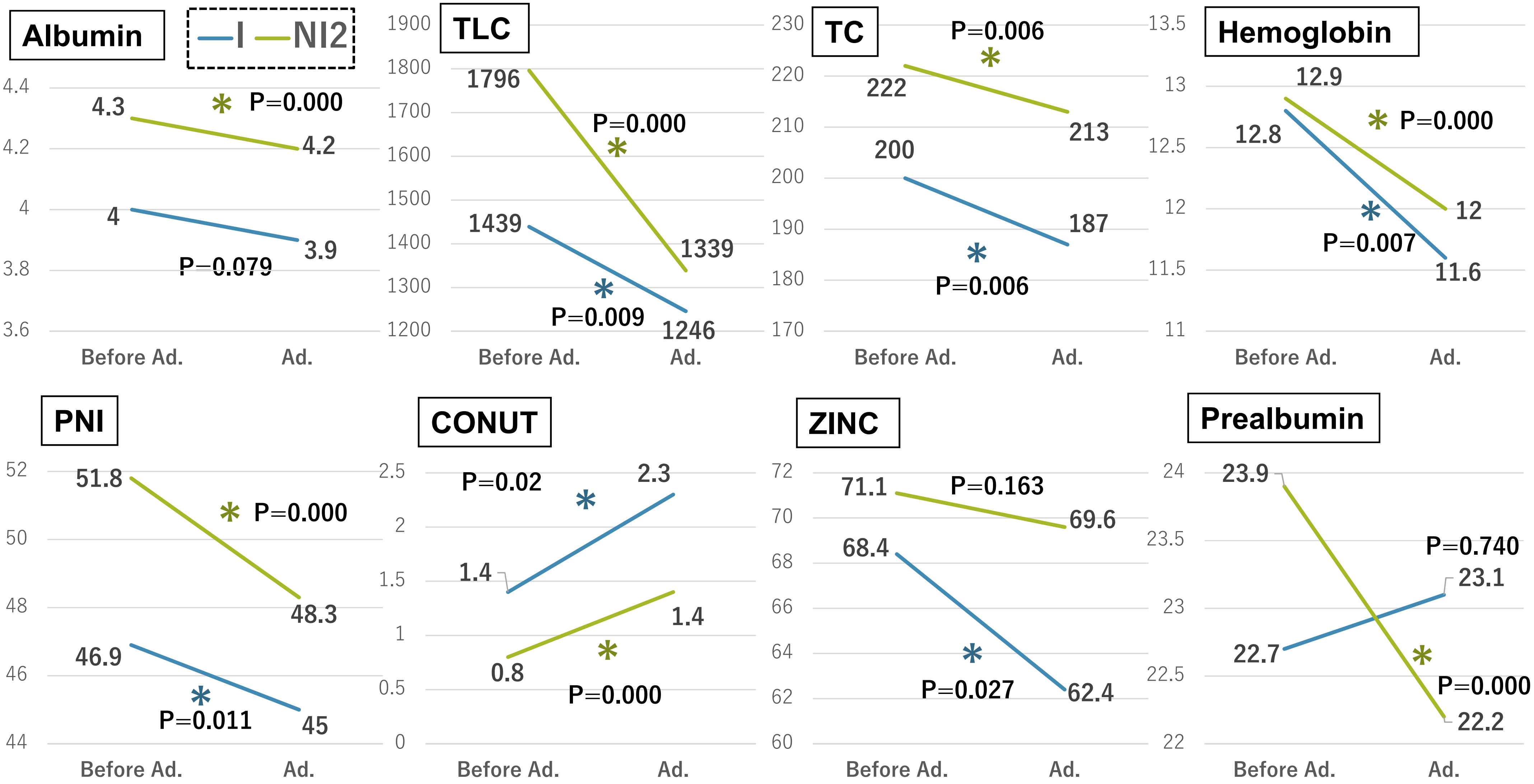
*: P<0.05, **: P<0.01, I2: nutritional intervention without autotransfusion, NI3: no nutritional intervention without autotransfusion since November 2018,
BMI; body mass index, PNI; Prognostic nutritional index, CONUT; Controlling nutrition status, ASA; American Society of Anesthesiologists,
CCI; Charson Comorbidity Index, SSI; surgical site infection

Figure 1.



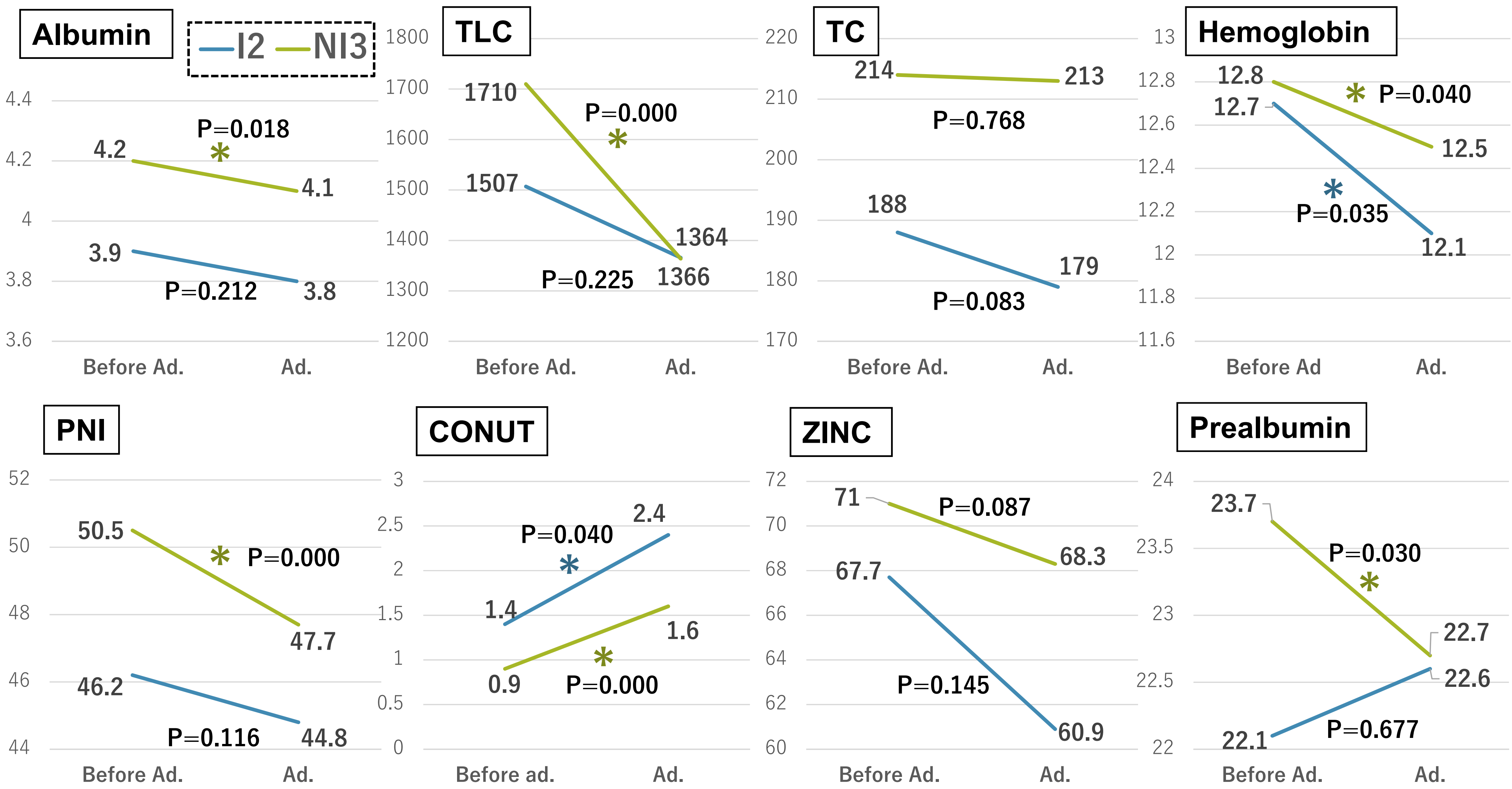
November 2018- November 2020
108 Pt.
PNI<50
PNI≥50
40 Pt.
68 Pt.
intervention
(+)
Intervention
(-)
Age<40
23 Pt.
Group I
24 Pt.
16 Pt.
45 Pt.
Autotransfusion
(+)
(-)
13 Pt.
11 Pt.
Group I2
61 Pt.
Group NI2
Autotransfusion
(+)
(-)
31 Pt.
30 Pt.
Group NI3
January 2014- October 2018
235 Pt.
PNI≥50
163 Pt.
72 Pt.
Age<40
2 Pt.
70 Pt.
Spinal tuberculosis
1 Pt.
69 Pt.
Group NI

Figure 2.



Albumin
I
NI2
4.4
4.2
4
3.8
3.6
4.3
4.2
4
3.9
P=0.000
P=0.079
Before Ad.
Ad.
TLC
1900
1800
1700
1600
1500
1400
1300
1200
1796
1439
1339
1246
P=0.000
P=0.009
Before Ad.
Ad.
TC
230
220
210
200
190
180
170
222
213
200
187
P=0.006
P=0.006
Before Ad.
Ad.
Hemoglobin
13.5
13
12.5
12
11.5
11
12.9
12.8
12
11.6
P=0.000
P=0.007
Before Ad.
Ad.
PNI
52
50
48
46
44
51.8
48.3
46.9
45
P=0.000
P=0.011
Before Ad.
Ad.
CONUT
2.5
2
1.5
1
0.5
0
P=0.02
2.3
1.4
1.4
0.8
P=0.000
Before Ad.
Ad.
ZINC
72
70
68
66
64
62
60
71.1
P=0.163
69.6
68.4
P=0.027
62.4
Before Ad.
Ad.
Prealbumin
24
23.5
23
22.5
22
23.9
P=0.740
23.1
22.7
P=0.000
22.2
Before Ad.
Ad.

Figure 3.


Albumin
I2
NI3
4.4
4.2
4
3.8
3.6
4.2
4.1
3.9
3.8
P=0.018
P=0.212
Before Ad.
Ad.
TLC
1800
1700
1600
1500
1400
1300
1200
1710
1507
1364
1366
P=0.000
P=0.225
Before Ad.
Ad.
TC
220
210
200
190
180
170
214
213
188
179
P=0.768
P=0.083
Before Ad.
Ad.
Hemoglobin
13
12.8
12.6
12.4
12.2
12
11.8
11.6
12.8
12.7
12.5
12.1
P=0.040
P=0.035
Before Ad
Ad.
PNI
52
50
48
46
44
50.5
47.7
46.2
44.8
P=0.000
P=0.116
Before Ad.
Ad.
CONUT
3
2.5
2
1.5
1
0.5
0
2.4
1.4
1.6
0.9
P=0.040
P=0.000
Before ad.
Ad.
ZINC
72
70
68
66
64
62
60
71
68.3
67.7
60.9
P=0.087
P=0.145
Before Ad.
Ad.
Prealbumin
24
23.5
23
22.5
22
23.7
22.7
22.6
22.1
P=0.030
P=0.677
Before Ad.
Ad.