



Title	Mini Nutritional Assessment as a useful method to predict the development of pressure ulcer among elderly inpatients
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26 **Running head:** Effectiveness of MNA for pressure ulcer prediction

27

28 **Abbreviations:**

29 PU, pressure ulcer; MNA, Mini Nutritional Assessment; SGA, Subjective Global Assessment;

30 BMI, body mass index; ROC, receiver operating characteristic; AUC, area under the curve; TP,

31 total protein; ChE, cholinesterase

32

33 **Abstract:**

34 **OBJECTIVES:** Malnutrition is a major risk factor of pressure ulcers (PU). However, the
35 best method of nutritional assessment to prevent PU is still unclear. This study was designed to
36 determine the usefulness of Mini Nutritional Assessment (MNA) and plasma amino acid analysis
37 to predict the formation of PU among inpatients.

38 **DESIGN:** This was a prospective, observational cohort study with a mean observation period
39 of 62.2±86.4 days.

40 **SETTING:** Intermediate and acute care wards of a hospital in rural Japan.

41 **PARTICIPANTS:** The 422 patients analyzed had an average age of 85.0±7.6 years.

42 **MEASUREMENTS:** MNA, Subjective Global Assessment (SGA), Braden Scale (PU
43 prognostic score), pressure ulcer formation, and biochemical analysis including plasma amino
44 acid concentrations.

45 **RESULTS:** PU developed in 7.1% of the patients. A MNA score of less than 8 was more
46 sensitive than a rating of moderate or severe malnourishment on the SGA combined with a
47 Braden Scale score of <15 in predicting future PU. Area under the receiver operating
48 characteristic curve (AUC) of MNA was superior to that of the Braden Scale. Braden Scale
49 nutrition subscore had the lowest AUC among the six Braden Scale subscores. The PU group
50 showed significantly lower plasma arginine concentrations than the No PU group.

51 **CONCLUSION:** MNA was able to predict the development of PU. A MNA of <8 performed
52 better than the SGA, Braden Scale, and plasma arginine levels in predicting PU development.
53 Although lower plasma arginine concentration at time of admission was associated with PU
54 development, the area under the ROC curve was not significant. The findings from this
55 prospective study support the use of nutritional assessment among inpatients in order to predict
56 PU risk and target appropriate interventions.

57 **Key Words:** Pressure ulcers, MNA, Braden Scale, arginine

58

59 **INTRODUCTION**

60 Protein-energy malnutrition is recognized as a major risk factor of pressure ulcers (PU).
61 The European Pressure Ulcer Advisory Panel (EPUAP) and National Pressure Ulcer Advisory
62 Panel (NPUAP) strongly recommend high-protein mixed oral nutritional supplements and/or
63 tube feeding, in addition to the usual diet, to individuals with significant nutritional risk and PU
64 risk¹. Also, the latest guidelines from the Japanese Society for Parenteral and Enteral Nutrition
65 support the efficacy of nutritional assessment and intervention to prevent and treat PU². There
66 are many methods for general nutritional assessment, one of which is the Mini Nutritional
67 Assessment (MNA) that was developed in the 1990s and has been suggested as a tool to predict
68 future development of PU³. However, the best method of nutritional assessment to prevent PU
69 remains controversial, and the MNA also has not yet been tested for its ability to predict pressure
70 ulcer development.

71 An ideal nutritional assessment should include dietetic, anthropometric and functional
72 parameters,⁴ and this is especially true for inpatients who face high PU risk and have access to
73 resources in order to perform the assessment. MNA includes these parameters.

74 The Braden Scale for Predicting Pressure Sore Risk (Braden Scale)⁵ is adopted widely for the
75 risk assessment of PU development, and the use of the Braden Scale is recommended by the
76 Japanese guidelines for prevention and management of pressure ulcers⁶. The Braden Scale
77 consists of 6 subscales, “friction and shear,” “sensory perception,” “moisture,” “activity,”
78 “mobility” and “nutrition.” According to a recent report, a total Braden Scale score has a
79 sensitivity of 65% and specificity of 70% in predicting PU formation in acutely ill adult
80 veterans⁷. The Braden Scale is easy to implement, however the nutrition category on the scale
81 only assesses usual food intake, which is largely subjective.

82 Furthermore, we have previously reported that plasma arginine levels were significantly

83 lower in percutaneous endoscopic gastrostomy patients with PU⁸. As arginine supplementation
84 improved PU healing in these patients^{8, 9}, depletion of plasma arginine may have a crucial role in
85 the pathophysiology of PU development. However, it is still unclear whether arginine
86 deficiency is a predisposing factor of PU.

87 Therefore, this study was primarily designed to determine the usefulness of MNA and
88 the Braden Scale to predict the onset of PU among Japanese inpatients in a prospective fashion.
89 Secondly, plasma amino acid analysis was also performed to see whether low plasma arginine at
90 the time of admission correlates with PU development during hospitalization.

91

92 **METHODS**

93 **Subjects**

94 All subjects admitted consecutively to the intermediate and acute care wards of Takada
95 Welfare Hospital during the study period (March, 2010 - March, 2011) were eligible for
96 enrollment regardless of the primary disease. All 438 eligible patients consented to participate.
97 Of those, 9 patients were excluded for incomplete data and 7 patients were excluded for
98 pre-existing pressure ulcers. The remaining 422 patients (age: range 61-102 years, 85.0 ± 7.6
99 years) were analyzed. The study was approved by the Institutional Review Board of Takada
100 Welfare Hospital (Fukushima, Japan). Study protocol was explained and written informed
101 consent was obtained from the patients or their relatives.

102 **Scoring MNA, SGA and Braden Scale**

103 Two trained nutritionists assessed the nutritional status of inpatients using MNA,
104 formerly called the Mini Nutritional Assessment-Short Form (MNA-SF). MNA is a clinical
105 tool that can be used to identify geriatric patients at risk of malnutrition. The MNA consists of
106 six questions, including food intake, weight loss, mobility, psychological stress or acute disease,

107 neuropsychological problems and body mass index (BMI) or calf circumference. These items
108 yield 0-2 points or 0-3 points, where 1 indicates poor function and 2 or 3 indicate normal
109 functions^{10, 11}. Scores from 12 to 14 points correspond to “normal nutritional status,” those
110 from 8 to 11 points are “at risk of malnutrition,” and those from 0 to 7 points are designated
111 “malnourished.”

112 Another nutritional status assessment tool is the Subjective Global Assessment (SGA)
113 outlined by Detsky and colleagues¹². The SGA classification employs historical data on weight
114 change, dietary intake, gastrointestinal symptoms and functional impairment. Physical
115 examination is also performed to detect clinical characteristics of undernutrition, such as loss of
116 subcutaneous fat and muscle wasting. The SGA rates patients into “well nourished,”
117 “moderately malnourished,” and “severely malnourished” groups, and was conventionally used
118 in the study hospital before MNA was adopted.

119 Braden Scale total scores were assessed by trained nurses in the study ward to estimate
120 the risk of pressure sore development. One registered nurse with a Wound, Ostomy and
121 Continence Nurse certification received formal training in Braden Scale scoring, and trained
122 other nurses by holding seminars as well as assessing the Braden Scale in volunteer patients.
123 The Braden Scale scoring was performed only for patients rated as “moderately” or “severely
124 malnourished” by SGA. The lowest and highest possible scores on the Braden Scale are 6 and
125 23, respectively, and patients with scores of <15 were defined as harboring a more than moderate
126 risk of PU development. Many studies have suggested that a score of <19 is the cutoff point for
127 risk of pressure ulcer development¹³, however the cutoff point with the best predictive accuracy
128 may depend on age and race¹⁴. The Japanese guidelines state that the cutoff point ranges
129 between 14 to 20⁶, and a cutoff of <15 is generally applied in Japan for inpatients. This cutoff
130 of <15 was adopted for this study. Those who scored <15 on the Braden Scale went through an

131 additional assessment for plasma amino acids, vitamins and trace elements.

132 **Determination of pressure ulcer development**

133 Ward nurses checked the skin status of patients daily to note the date of PU formation,
134 and new incidence of PU development was judged at biweekly rounds of pressure ulcer
135 assessment panel independent from this study. Pressure ulcer with depth of d2 or greater in
136 DESIGN-R, which is equivalent of Stage II or greater in NPUAP and Grade II or greater in
137 EPUAP, was judged as PU development. DESIGN-R is a pressure ulcer scale developed by the
138 Japanese Society of Pressure Ulcers. DESIGN-R d2 does not include skin redness, which is a
139 sign of deep tissue injury. Screening for deep tissue injury by skin ultrasound was not
140 performed in this study, and therefore deep tissue injuries may not have been judged as PU
141 formation. In this study, repeated admissions of the same patient were counted as one stay, and
142 only newly-developed open pressure ulcer sores that developed in the facility or between
143 admissions were counted in the study.

144 **Laboratory Testing**

145 Total protein, albumin, C-reactive protein (CRP), aspartate amino transferase (AST),
146 alanine amino transferase (ALT), cholinesterase (ChE), blood urea nitrogen (BUN), creatinine,
147 triglyceride (TG), and fasting plasma glucose (FPG) were measured in the hospital laboratory
148 with the Hitachi Autoanalyzer 7070 (Hitachi High-Technologies Corporation, Tokyo, Japan) and
149 complete blood count was measured by XT-1800i (Sysmex, Kobe, Japan) as routine admission
150 tests in most of the patients. Plasma amino acid analysis was performed using
151 high-performance liquid chromatography. Amino acid analysis and measurements of
152 phosphorus, copper, zinc, vitamin A, B1, E and insulin were performed only in those who were
153 rated moderately or severely malnourished by the SGA and scored <15 on the Braden Scale.
154 These measurements were performed by SRL Inc. (Tokyo, Japan). Blood for biochemical

155 analyses was drawn from patients upon admission after overnight fast.

156 **Statistical Analysis**

157 Only research doctors who were not directly involved in the data collection performed
158 statistical analyses. Statistical differences between the PU group and the No PU group at the
159 time of enrollment were analyzed by unpaired t-test. Data are given as mean \pm SD. Pair wise
160 test and area under the ROC curve analysis were performed by GraphPad Prism version 5
161 (GraphPad Software Inc., La Jolla, CA), and multiple regression analyses were performed using
162 IBM SPSS Statistics 17 (IBM corporation, Armonk, NY). Significance was denoted at $P < 0.05$.

163

164 **RESULTS**

165 **Basic characteristics and outcome**

166 The average age of all patients was 85.0 ± 7.6 years (Table 1). Of the 422 patients
167 enrolled, 30 (7.1%) developed PU during a mean follow-up period of 62.2 ± 86.4 days. The
168 BMI of the patients who developed PU were significantly lower than that of those who did not,
169 but there was no significant difference in age between the groups (Table 1). Also, there were
170 significant differences in the total days of hospital stay (PU: 111 ± 108 days vs. No PU: 42 ± 65
171 days, $P = 0.002$) and the lengths of follow up (PU: 129 ± 119 days vs. No PU: 57 ± 81 days,
172 $P = 0.003$).

173 The Braden Scale was assessed in 239 subjects who were determined by SGA to face
174 moderate or high nutritional risk. Of those, 104 patients scored less than 15 and were
175 determined as being at high risk by the Braden Scale, and from this group, 17 developed PU
176 during hospitalization. However, 3 out of the 183 subjects who were determined by SGA to be
177 “well-nourished” and 10 out of the 135 patients who scored 15 or above on the Braden Scale also
178 developed PU. Therefore, a SGA rating of moderately or severely malnourished combined with

179 a Braden Scale score of less than 15 had a sensitivity of 57% and a specificity of 78% to detect
180 future PU in this population (Table 2). In contrast, using MNA, only 5 patients in the whole
181 study population were determined as “well-nourished.” Twenty-nine out of 30 patients who
182 developed PU scored <8 on the MNA and belonged to the “malnourished” group and the
183 remaining one patient was determined as being “at a risk of malnutrition.” Therefore, MNA
184 with a cut-off of <8 showed a very high sensitivity of 97% but low specificity of 42% to predict
185 the onset of PU (Table 2). The negative predictive value of the MNA (<8) was also better than
186 that of the SGA (moderately or severely malnourished) combined with the Braden Scale (<15).
187 However, the specificity and positive predictive values of the MNA were lower than those of the
188 combined SGA and Braden Scale (Table 2). The ROC curve of MNA in all patients was
189 superior to that of the Braden Scale among those who were rated moderately or severely
190 malnourished by the SGA (Figure 1).

191 **Multiple logistic regression model for the prediction of pressure ulcer development using** 192 **MNA**

193 Multiple logistic regression model analysis showed that MNA independently and
194 significantly associated with PU development in all subjects after adjusting for age, sex, and
195 BMI (Table 3). When TP, albumin, ChE, and TG were also adjusted, only the MNA was
196 significantly associated with PU development (odds ratio 0.715, 95% confidence interval:
197 0.546-0.937, P=0.015, n=252).

198 **Subscore analysis in Braden Scale**

199 To assess the association and prediction accuracy of each query, subscores of the Braden
200 Scale were individually analyzed by pair-wise t-test and ROC analysis (Table 4). There was a
201 significant difference in the total score and the sensory perception, activity, mobility, and
202 friction/shear subscores between the PU and No PU groups. The nutrition and moisture

203 subscores were not significantly different between the PU and No PU groups, and the ROC
204 analyses were not significant for these subscores. However, the nutrition subscore showed the
205 lowest AUC, signifying a weakness of the Braden Scale in nutritional assessment.

206 **Biochemical profile of patients who developed PU**

207 In routine laboratory testing, TP, albumin, ChE, and TG were significantly lower in the
208 PU group than in the No PU group (Table 5). More detailed screenings for biochemical
209 analysis were performed in patients who were rated moderately or severely malnourished by the
210 SGA and scored <15 on the Braden Scale. Total amino acid, essential amino acid and
211 branched-chain amino acid levels were not significantly different between the patients who
212 developed PU and those who did not (data not shown). However, plasma arginine
213 concentrations were significantly lower in the PU group compared to the No PU group (Table 5).
214 For vitamins and minerals, the PU group showed significantly lower serum vitamin A (Table 5)
215 than the No PU group, with no significant differences in the levels of phosphorus, copper,
216 vitamins B1 and E and zinc (data not shown).

217

218 **DISCUSSION**

219 This study showed a significant benefit of nutritional assessment for the prediction of
220 future PU development. The major findings include; the effectiveness of the MNA; insufficient
221 power of the Braden Scale in the nutrition subscore; and the possible utility of serum arginine
222 concentration as an index of PU risk.

223 The current report, for the first time, shows that the MNA has a sufficient capability to
224 assess future risk of PU among aged inpatients. The usefulness of the Braden Scale has been
225 reported in many previous studies^{15, 16}. However, in this study, an MNA rating of less than 8
226 had better sensitivity and negative predictive value than a SGA rating of moderately or severely

227 malnourished combined with a Braden Scale score of less than 15, and the area under the ROC
228 curve of MNA in all patients was superior to that of the Braden Scale in patients rated
229 moderately or severely malnourished by SGA. Among our test subjects, use of the Braden
230 Scale led to an increase in false negatives that may benefit from more aggressive intervention.

231 Nutritional status is considered one of the most important factors influencing the
232 pathophysiology of PU. For example, Lahmann et al. reported that nutrition is the second
233 strongest predictor of PU in long-term care residents in Germany¹⁷. Furthermore, among
234 patients with PU, simple accumulation of caloric intake helped PU healing¹⁸. The MNA has
235 been validated by many researchers for its effectiveness to identify geriatric patients who are
236 malnourished or at risk of malnutrition¹⁹. By our study showing the usefulness of the MNA in
237 assessing PU risk, the importance of nutritional status in the formation of PU was reinforced.

238 In fact, the weakest aspect of the Braden Scale may be in its nutrition assessment. Our
239 study showed that of the 6 Braden Scale subscales, the nutrition subscale was not a significant
240 predictor of PU by ROC analysis and did not show any significant differences between the PU
241 and No PU groups. Also, it has been reported that the modified Braden Scale excluding
242 nutrition subscore was more predictive of PU development than the conventional Braden Scale²⁰.
243 The Braden Scale nutrition subscale gives scores of 1 (very poor) to 4 (excellent) based on usual
244 food intake pattern. A questionnaire-based assessment such as the Braden Scale is easy to
245 adopt in a domestic setting, but can be very subjective. In medical facilities where advanced
246 physical assessment is possible and the formation of PU is frequent, more detailed and
247 quantitative methods such as measurement of BMI may be suitable²¹. Since the MNA adopts
248 BMI or calf circumference to assess current nourishment, malnutrition predisposing to PU
249 development may be detected more effectively than the corresponding questionnaire in the
250 Braden Scale.

251 A possible problem of adopting the MNA over the Braden Scale for inpatients is its low
252 specificity and low positive predictive value. This may increase the number of patients
253 requiring nutritional intervention. PU formation occurs in only a minor subset of patients, but
254 the morbidity, its damage to the quality of life, and the cost of PU can be great. Among
255 inpatients, the incidence of PU formation is higher than in other populations, and if nutritional
256 risk for PU is found, there are more possible interventions to prevent PU in a hospital compared
257 to other settings. In addition, nutritional improvement has been shown to improve general
258 condition of the patients including the healing of primary disease. As such, the use of screening
259 measures with high sensitivity may be justified, even if they have somewhat lower specificity.
260 However, the effectiveness of specific interventions needs to be tested in the future.

261 Another notable finding from this prospective observational study is that the patients
262 who developed PU during hospital observation showed lower plasma concentrations of arginine
263 at admission than those who did not develop PU. We have previously reported that inpatients
264 with PU showed significantly lower plasma arginine concentrations than those without PU⁸.
265 Also, we and others have shown that oral arginine supplementation may improve PU healing^{8 9}.
266 However, the question remains as to whether chronic arginine deficiency leads to PU formation.
267 Research to date has shown that arginine metabolism produces nitric oxide, which is essential in
268 wound healing²². Arginine is also reported to be beneficial in maintaining tissue integrity and
269 facilitating wound healing²³. Moreover, it has been demonstrated that orally administered
270 arginine can be effectively absorbed and utilized²⁴. In this prospective study, arginine depletion
271 correlated with PU development however the ROC curve analysis for arginine was not
272 significant. As such, plasma arginine concentration by itself may not sufficiently predict PU
273 development, but whether arginine supplementation in patients with low plasma arginine has a
274 preventive effect on PU formation remains to be investigated.

275 Besides arginine, lower plasma concentrations of vitamin A correlated with PU
276 development. Vitamin A deficiency is reported to inhibit wound healing through decreased
277 collagen reconstruction and impaired re-epithelialization²⁵. In a previous report, inpatients with
278 PU showed lower serum vitamin A concentration compared to those without PU⁸. We have also
279 reported that L-arginine- and zinc-rich formula increased plasma arginine concentration and
280 improved the rate of PU healing in patients on tube feeding.⁸ To determine the efficacy and
281 efficiency of nutrient-specific supplementation to prevent PU, a prospective, randomized,
282 controlled intervention trial will be necessary.

283 In addition to arginine and vitamin A, concentrations of total protein, albumin,
284 cholinesterase and triglycerides were significantly lower in those who developed PU than those
285 who did not. These plasma proteins and lipids have been reported to significantly correlate
286 with nutritional status²⁶. The result of this study is reasonable as those who developed PU had
287 lower nutritional status, as determined by significantly lower MNA scores, compared to those
288 who did not develop PU. In this study, the average lengths of hospital stays were significantly
289 different between the PU and No PU groups. The length of hospital stay is suggested as a
290 predisposing factor of PU development, and a poor nutritional status may also be a predisposing
291 factor for longer hospital stay. This may be investigated as a topic for future research.

292 One of the limitations of this study was that Braden Scores and detailed biochemical
293 analyses including plasma amino acid concentrations were assayed only in those rated
294 moderately or severely malnourished by the SGA. This method makes it difficult to compare
295 the MNA and Braden Scale directly, but was applied due to personnel and financial constraints.
296 Another limitation of the study is that inter-rater reliability was not assessed for the MNA, SGA
297 and Braden Scale scoring, although the benefit of the MNA is that it does not require formal
298 training, and its inter-rater reliability has been validated in a previous report²⁷. Also, this study

299 used a Braden Scale cutoff point of <15 as opposed to <19, which is used in many other studies.
300 This was done according to the recommendation of the Japanese Society of Pressure Ulcers, but
301 it limits the comparison of data with other studies.

302 **CONCLUSION**

303 Geriatric inpatients with malnutrition as assessed by MNA were more likely to develop
304 PU, and those who developed PU showed lower plasma arginine concentrations than those who
305 did not. An MNA rating of <8 performed better than the SGA, Braden Scale, or arginine levels
306 in predicting PU development. Although lower plasma arginine concentration at time of
307 admission was associated with PU development, the area under the ROC curve was not
308 significant. Supplementation of arginine based on amino acid profiling may be useful for the
309 prevention of PU.

310 **ACKNOWLEDGMENTS**

311 **Author Contributions:** MSY is the corresponding author and designed the study JY. FT, II
312 and AS helped with data collection. TK provided nutritional consultation. SU provided
313 authorization for this study and aided the acquisition of subjects. Kozue Takano built the
314 patient data registry. TW and HS provided advice for this study. JY performed analysis and
315 interpretation of the data and prepared the manuscript with MSY.

316

317 **Sponsor's Role:** None

318

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388

389

390 **Tables**

391

392 Table 1. Basic characteristics

393

	Scores	All	No PU (392)	PU (30)
Age (years)		85.0±7.6	86.8±7.5	84.8±7.5
Female ratio (%)		61.4	62.5	46.7
BMI (kg/m ²)		21.5±4.1	21.7±4.2	19.6±3.1*
SGA +	Low risk	318	305	13
Braden Scale	High risk	104	87	17
(persons)	12-14	5	5	0
MNA	8-11	160	159	1
(persons)	0-7	257	228	29

394 PU: pressure ulcer, BMI; body mass index, SGA: Subjective Global Assessment, MNA: Mini

395 Nutritional Assessment. High risk by SGA + Braden Scale denotes SGA at moderate or high

396 risk and Braden Scale below 15. *P<0.05, No PU vs. PU. Chi-square test for sex, t-test for

397 age and BMI.

398

399

400 Table 2. Predictive values of the Braden Scale and MNA

401

Cut-off	Sensitivity	Specificity	PPV	NPV
SGA + Braden Scale (Moderate/severe + <15)	0.57	0.78	0.16	0.96
MNA (<8)	0.97	0.42	0.11	0.99

402 SGA: Subjective Global Assessment, MNA: Mini Nutritional Assessment, PPV: positive

403 predictive value, NPV: negative predictive value.

404

405 Table 3. Multiple logistic regression model for pressure ulcer development

406

variables	β	SE	Wald	P value	Odds ratio	95 % CI
intercept	-0.79	2.7				
age	0.09	0.029	0.094	0.759	1.009	0.953-1.069
Sex (female)	-1.116	0.433	6.644	0.010	0.328	0.140-0.765
BMI	0.017	0.062	0.072	0.788	1.017	0.900-1.149
MNA	-0.423	0.105	16.113	<0.001	0.655	0.533-0.805

407 N = 422. CI: confidence intervals, BMI: body mass index, MNA: Mini Nutritional Assessment

408

409

410 Table 4. Braden Scale subscore analysis

411

	No PU (n=212)	PU (n=27)	P value (t-test)	AUC	P value (ROC)
Sensory perception	3.5±0.7	3.1±0.8	0.03	0.634	0.02
Moisture	3.0±1.1	2.7±1.0	0.1	0.606	0.07
Activity	2.5±1.1	1.7±0.8	<0.001	0.702	<0.001
Mobility	3.0±1.0	2.4±1.0	0.007	0.658	0.007
Nutrition	2.4±1.1	2.1±1.2	0.2	0.572	0.2
Friction and shear	2.1±0.8	1.3±0.6	<0.001	0.713	<0.001
total score	16.5±4.8	13.4±3.9	<0.001	0.689	0.001

412 PU: pressure ulcer. Mean±SD. AUC: area under the receiver-operator characteristic curve.

413 P value for ROC analysis was evaluated by testing the null hypothesis that the area under the

414 curve really equals 0.50.

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416

417

418 Table 5. Laboratory tests with significant differences between No PU and PU patient groups

419

		No PU	PU	P value
Total protein	g/dl	6.6±0.7 (334)	6.1±0.8 (26)	0.01
Albumin	g/dl	3.5±0.6 (325)	3.0±0.6 (27)	0.001
ChE	U/l	216±76 (314)	169±50 (24)	<0.001
Triglyceride	mg/dl	88.9±39.5 (303)	70.9±18.2 (21)	<0.001
Vitamin A	IU/dl	79.0±43.1 (99)	58.4±32.5 (17)	0.02
Arginine	nmol/ml	82.6±23.7 (99)	71.6±16.8 (17)	0.04

420

421 PU: pressure ulcer, ChE: cholinesterase. Mean±SD. Numbers of patients are shown in

422 parentheses. Vitamin A, and arginine concentrations were measured only in those who were

423 rated moderately or severely malnourished by SGA and scored <15 on the Braden Scale. The

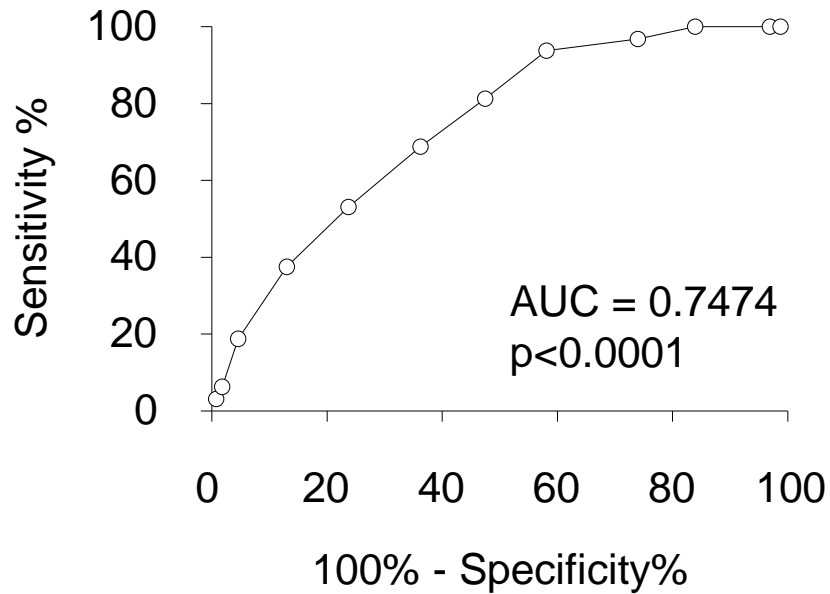
424 normal serum concentration range is 97 to 316 IU/dl for vitamin A. The normal plasma

425 concentration range of arginine is 53.6 to 133.6 nmol/ml.

426

Figure 1

A) MNA



B) Braden Scale

