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Original article

Insulin-like growth factor-1 as a nutritional monitoring factor in patients with chronic intestinal failure

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SUMMARY

Background & aims: Nutritional monitoring plays an important role in optimizing nutritional support in patients with chronic intestinal failure (CIF) receiving long-term supplementation. Unlike initial nutritional assessment, however, there are no recommended guidelines for establishing a nutritional monitoring index. This study is to evaluate the suitability of insulin-like growth factor-1 (IGF-1) as a nutritional monitoring factor in CIF patients.
Methods: We retrospectively analyzed the correlation between serum nutritional indicators, including IGF-1 levels, and nutritional assessment, nutritional monitoring, and lean body mass in 197 patients with CIF.
Results: The mean age of the 197 enrolled patients was 47.22 ± 18.87 years old and; the mean BMI was 16.83 ± 3.31. The mean NRS-2002 score was 3.49 ± 0.83; and moreover, 76.3% of the patients were malnourished. The median length of hospital stay in hospital (LOS) was 18.5 days. IGF-1 was positively correlated with body mass index, hemoglobin, albumin, pre-albumin, retinol-binding protein (RBP), transferrin, serum creatinine (Scr) and cholesterol ($p < 0.05$ for all). Testing performed over 3 weeks post-admission showed that significantly different weekly changes were observed only in IGF-1, RBP, and Scr during the period of nutritional support ($p < 0.05$ for each). Multivariate linear regression analysis showed that IGF-1 and body mass index were independent factors influencing fat-free mass, skeletal muscle mass, and body protein mass ($p < 0.05$ for each).
Conclusions: IGF-1 is suitable for monitoring short-term changes in the nutritional status in CIF patients. This may be attributed to its shorter half-life, greater sensitivity, and better correlation with lean body mass. ClinicalTrials.gov number, NCT03277014.

1. Introduction

Chronic intestinal failure (CIF) is one of the rarest of organ failures all over the world, mainly caused by severe gastrointestinal or systemic benign diseases such as intestinal fistula, short bowel, and mechanical obstruction [1,2]. Moreover, patients with end-stage intra-abdominal or pelvic cancer can also develop into CIF [2,3]. CIF is defined as gut function that is below the minimum necessary for the absorption of macronutrients and/or water and electrolytes; in such cases, nutrition support, especially via parenteral nutrition, is indispensable to maintain health and recovery for CIF patients [2].

Nutrition support has successfully saved the lives of thousands of patients with CIF, as well as those who have critical illnesses or underwent surgery [4,5]. According to the guidelines, patients with

Abbreviations: BMI, body mass index; CIF, chronic intestinal failure; FFM, fat-free mass; IGF-1, insulin-like growth factor-1; NRS-2002, Nutritional Risk Screening 2002; NUTRIC, nutrition risk in the critically ill; SGA, Subjective global assessment; RBP, retinol-binding protein; Scr, serum creatinine; SMM, skeletal muscle mass.

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CIF require parenteral nutrition over periods of weeks or months and the efficiency of nutrition support will influence the prognoses directly [1,2]. The exact nutritional assessment and close nutritional monitoring are key points to optimize nutritional therapy. Firstly, the recommended scoring systems such as the Nutritional Risk Screening 2002 (NRS-2002) score or the 'nutrition risk in the critically ill' (NUTRIC) score can identify patients who are at nutritional risk and who would benefit from nutritional support [5–7]. Secondly, nutritional support regimens should be individualized and adjusted over time based on continuous monitoring; however, there are no guidelines regarding such nutritional monitoring. The NRS-2002 and NUTRIC scores are recommended as initial nutritional assessment indices, but are inappropriate for continuous evaluation. Moreover, validated nutritional indicators that can be used for monitoring short-term nutritional status changes were still unclear. Nowadays, common serum protein markers such like albumin, prealbumin, transferrin, and retinol-binding protein (RBP) are used to monitor the efficiency of nutritional support in clinical practice [5,8]. However, all these nutritional indicators failed to reflect changes of nutritional status with sufficient sensitivity in CIF patients [5,6,9–11].

Insulin-like growth factor-1 (IGF-1) is an IGF family member that consists of 70 amino acid residues [9,12]. IGF-I was first reported as a nutritional marker in 1973 because its serum concentrations are reduced during malnutrition [13]; its serum levels also proved to be affected by protein or/and energy deficiency [9,14,15]. Several previous studies reported that IGF-1 is a more sensitive and specific indicator of nutritional status than prealbumin, transferrin, or RBP because of its shorter serum half-life and more accurate response to nutritional intake; however, these studies had small cohorts [8,9,16].

In present study, we compared IGF-1 to traditional serum nutritional indicators in terms of diagnosing nutritional risk and malnutrition, as well as in monitoring the efficiency of nutrition support in CIF patients. We also determine the relationship between IGF-1 and each of free fat mass, skeletal muscle mass and body protein mass.

2. Methods

We conducted a retrospective study of patients treated at a single clinical nutrition center of a tertiary referral hospital in China to investigate whether the measurement of IGF-1 is useful for monitoring the efficiency of nutritional support and to explore the relationship between IGF-1 and lean body mass in CIF patients. The data used were accumulated at the center between September 2013 and January 2017. All adult CIF patients (age $\geq$18 years) receiving nutrition support were included. The exclusion criteria were hepatic insufficiency (alanine transaminase/aspartate transaminase ratio 200% above normal range or bilirubin >3 mg/dL), renal insufficiency (serum creatinine [Scr] >1.5 mg/dL), acute or life-threatening diseases (e.g., shock, collapse, stroke, coma of unknown etiology, or recent cardiac infarction), and pregnant or breast-feeding women. The study was approved by the ethics committee of Jinling Hospital, Medical School of Nanjing University.

Malnutrition was defined as unintentional weight loss >10% within 6 months, a body mass index (BMI) <18.5, a subjective global assessment (SGA) score of stage C, or albumin level <30 g/L [17,18]. Serum IGF-1, albumin, pre-albumin, transferrin, RBP, creatinine, and hemoglobin were measured weekly in patients receiving nutrition support after hospital admission. The resting energy expenditure, predicted weekly by indirect calorimetry (Quark PFT ERGO, COSMED Srl - Italy), was used to guide energy delivery. The target dose of protein intake was 1.2 g/kg/day, which was adjusted according to the nitrogen balance and the level of serum albuminmarker. Patients were also subjected to strict fluid intake management. The nutritional support schemes were recorded daily, and the body composition was also measured weekly to estimate nutrition status (Inbody S10, Biospace).

2.1. Statistical analysis

Data are reported as mean ± standard deviations for normally distributed variables and median (first-to-third interquartile range) for non-normal data. Correlations between measurement data were estimated using Pearson's correlation coefficient, and categorical variables were determined by using Spearman rank correlation values. The receiver operating characteristic curve was used to estimate the diagnostic efficacy of IGF-1 in malnutrition, and repeated measures analysis was used to evaluate the time trends of different variables. Multivariate linear regression models were used to identify the independent factors influencing fat-free mass (FFM), skeletal muscle mass (SMM), and body protein mass. All statistical computations were performed using the Statistical Package for the Social Sciences, SPPS 20.0 (SPSS, Chicago, IL). For all tests, $p < 0.05$ was considered statistically significant.

3. Results

A total of 281 patients were admitted to our clinical nutrition center between September 2013 and January 2017. Forty-eight patients received enteral but not parenteral nutrition. Among the 233 CIF patients receiving parenteral nutrition, 21 were under 18 years old and were excluded; moreover, 8 patients with hepatic insufficiency, 3 with renal insufficiency, 3 with acute or life-threatening diseases, and 1 who was pregnant were also excluded (Fig. 1).

3.1. Demographic information and clinical data of the CIF patients

The mean age of the 197 enrolled patients was 47.22 ± 18.87 years; 106 were women. The mean body weight was 45.52 ± 10.62 (kg), the mean BMI was 16.83 ± 3.31, and the mean NRS-2002 score was 3.49 ± 0.83; moreover, 76.3% of the patients were malnourished. The median length of hospital stay was 18.5 days (Table 1). The mean levels of IGF-1, hemoglobin, albumin, pre-albumin, RBP, transferrin and Scr were 105.47 ± 81.59 ng/mL, 109.30 ± 21.94 g/L, 37.190 ± 6.30 g/L, 170.01 ± 88.14 mg/L, 34.71 ± 18.24 mg/L, 2.45 ± 0.80 g/L, 60.42 ± 40.40 umol/L respectively.

3.2. Correlation between IGF-1 and traditional nutrition assessment indices

Figure 2 shows that except serum creatinine ($r = 0.130$, $p = 0.095$), IGF-1 was positively correlated with BMI ($r = 0.322$, $p < 0.001$), hemoglobin ($r = 0.474$, $p < 0.001$), albumin ($r = 0.438$, $p < 0.001$), pre-albumin ($r = 0.695$, $p < 0.001$), RBP ($r = 0.363$, $p < 0.001$), transferrin ($r = 0.550$, $p < 0.001$). The nutritional risk and malnutrition were negatively correlated with IGF-1 at admission (both $p < 0.001$). Compared with all other nutritional indicators except BMI, IGF-1 was more reliable for diagnosing malnutrition. The area under the curve for IGF-1 was 0.815 and the

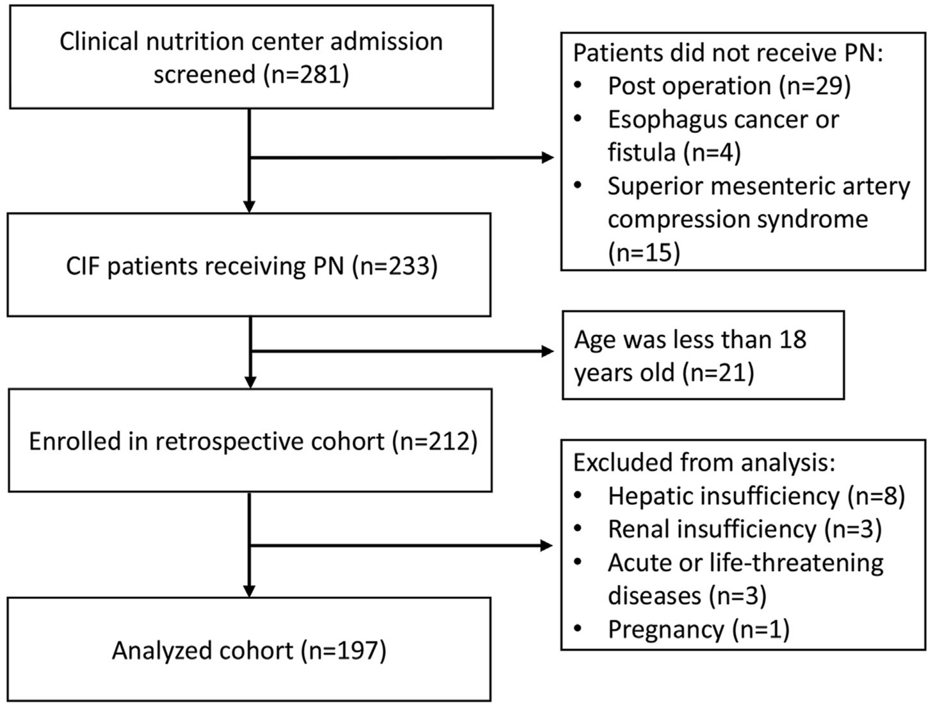

Fig. 1. Study design and patient selection. PN, Parenteral nutrition; CIF, Chronic intestinal failure.

corresponding sensitivity and specificity were 0.667 and 0.875 respectively when the optimal cut-off value for IGF-1 to diagnose malnourishment IGF-1 was 83.5 ng/mL; the results of receiver operating characteristic analysis of the malnutrition index are shown in Fig. 3 and Table 2.

Table 1
Demographic and clinical information for chronic intestinal failure patients.

Characteristic	Value
n	197
Age	47.22 ± 18.87
Female	106
Male	91
Body Weight (kg)	45.52 ± 10.62
BMI	16.83 ± 3.31
NRS2002	3.49 ± 0.83
IGF-1 (ng/mL)	105.47 ± 81.59
LOS (Days)	18.50 (12.00, 29.00)
Malnutrition (%)	76.3%
SGA class (A; B; C)	15; 76; 94
Etiology of malnutrition	
SBS	25
Ileus	75
Gastrointestinal mucosa diseases	26
Severe Stress or Wasting conditions	34
Gastrointestinal dysfunction	35
Others	2
Skeletal muscle mass (kg)	20.53 ± 5.40
Body protein mass (kg)	7.46 ± 1.82
Fat free mass (kg)	39.06 ± 9.14
Basal metabolic rate (kcal/kg)	28.04 ± 4.52
Daily energy (kcal/kg)	27.80 ± 10.10
Daily protein (g/kg)	1.21 ± 0.47
Daily energy via EN (kcal/kg)	13.30 ± 10.53
Daily energy via PN (kcal/kg)	14.75 ± 9.62

Values are presented as mean ± SD or median (first-to-third interquartile range); BMI, Body mass index; IGF-1, Insulin-like growth factor-1; LOS, Length of stay in hospital; SGA, Subjective Global Assessment of nutritional status method; SBS, Short bowel syndrome.

3.3. Changes in nutritional indicator levels during nutritional support

The results of tests performed at 3 time points (baseline, week 1, and week 2 after admission) indicated that IGF-1, lymphocyte count, albumin, pre-albumin, RBP, and Scr changed significantly over this period ($p < 0.05$) (Table 3). However, tests performed at 4 time points (baseline, week 1, week 2, and week 3 after admission) showed significantly different weekly changes only in IGF-1, RBP, and Scr during nutritional support ($p < 0.05$) (Fig. 4). The changes of IGF-1 were still significantly different weekly after adjusted for age, sex, diseases and C-reactive protein ($F = 4.277$, $p = 0.008$). In addition, the results showed that there were no significant interaction effects between Time and Age ($F = 0.780$, $p = 0.509$), sex ($F = 0.419$, $p = 0.740$), diseases ($F = 2.215$, $p = 0.095$) and C-reactive protein ($F = 1.790$, $p = 0.158$).

3.4. IGF-1 was independently associated with FFM, SMM, and body protein mass

Univariate analysis showed that age, sex, BMI, malnutrition, IGF-1, pre-albumin, RBP, and Scr were significantly correlated with FFM, SMM, and protein ($p < 0.05$ for all) (Table 4). A multivariate linear regression model revealed that IGF-1 and BMI were independent factors influencing FFM, SMM, and protein (Tables 5–7).

4. Discussion

Chronic Intestinal Failure (CIF) is one of the rarest and most serious diseases, characterized with long-lasting reduction of gut function. Nutrition support is critical to a vast number of patients who are hospitalized annually because of critical illnesses or surgery. It is also necessary for patients with CIF, who often require

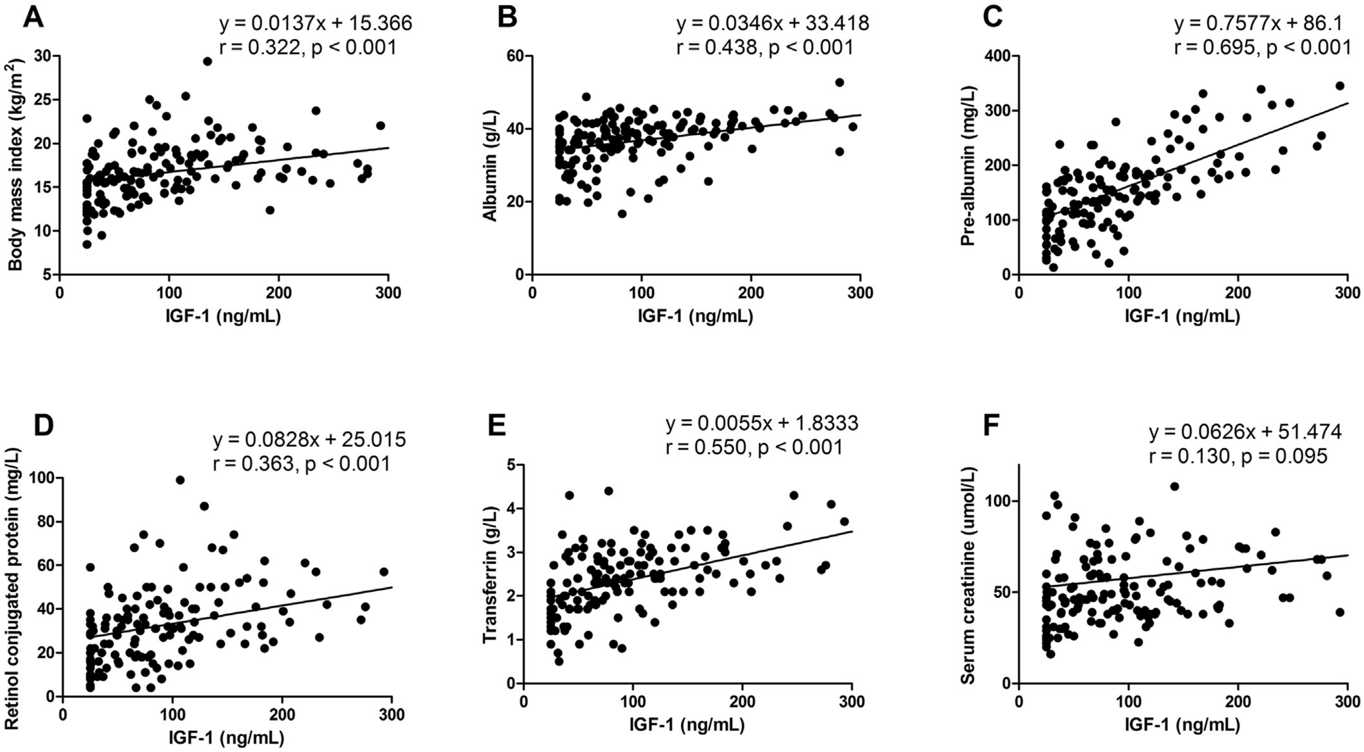

Fig. 2. The bivariate linear correlation analysis between IGF-1 and traditional nutritional assessment index. A, IGF-1 is correlated with body mass index; B, IGF-1 is correlated with albumin; C, IGF-1 is correlated with pre-albumin; D, IGF-1 is correlated with retinol conjugated protein; E, IGF-1 is correlated with transferrin; F, IGF-1 is uncorrelated with serum creatinine. IGF-1, Insulin-like growth factor-1.

parenteral nutrition over periods of weeks or months [2]. Nutritional assessment is related to clinical prognosis, and current guidelines recommend the NRS-2002 or NUTRIC score as an indicator of patients who will benefit from nutritional support at the time of admission to hospital [5,19,20]. Patients at high nutritional risk or malnutrition require nutritional supplementation with individualized regimens that are adjusted over time, especially in those requiring long-term nutritional support such as CIF patients. However, the methods to monitor the efficacy of continuous nutritional support remain unclear.

IGF-1 has reportedly been used as a nutritional indicator to evaluate the nutritional status of patients with short bowel syndrome, cancer, and acute kidney injury, as well as surgical patients and children on hemodialysis among others [21–26]. However, because IGF-1 has only been investigated as a nutritional indicator of short-term nutritional support efficiency in studies that enrolled only a few patients (e.g., 6 malnourished patients), the rationale for applying IGF-1 monitoring to patients requiring nutritional support monitoring has been lacking [8,9,16].

In our study, we first systematically evaluated the correlation between IGF-1 and the traditional nutrition assessment index. The results showed that IGF-1 is positively correlated with BMI, hemoglobin, albumin, pre-albumin, RBP, transferrin, Scr, and cholesterol. Our results were consistent with previous studies that showed IGF-1 to be correlated with BMI and other nutritional indicators [27,28]. Next, we found that most nutritional assessment indicators even at diagnosis of malnutrition were within the normal range except IGF-1, albumin and pre-albumin. In addition, IGF-1 has a greater sensitivity and specificity for diagnosing malnutrition compared to other nutritional indicators. Regardless of these findings, however, we do not suggest that IGF-1 should be used routinely in nutritional assessment. On one hand, BMI and SGA were superior to IGF-1 for diagnosing malnutrition in our study; on the other, IGF-1 can also be influenced by age, sex, genetic factors, acute-phase response, and endocrine conditions in addition to malnutrition [9,29–33].

Anthropometric measurements and other nutritional indicators were evaluated for their ability to monitor short-term nutritional status changes or nutritional support efficiency. However, BMI proved useful only for assessing long-term nutritional status changes [34]. Albumin and pre-albumin, which have relatively longer half-lives, showed lower sensitivity [9]. To determine whether IGF-1 was more sensitive than other nutritional indicators in response to short-term nutritional status changes, we performed a time-trend analysis in which we found that the levels of IGF-1, RBP, Scr, lymphocyte count, albumin, and pre-albumin were significantly different with each other among 3 time points within 2 weeks. When the test period was extended to 3 weeks, only IGF-1, Scr, and RBP showed significantly different time-trend changes. These results indicated that IGF-1 together with Scr and RBP are more sensitive for monitoring short-term nutritional status changes. These values were determined at 2 and 3 weeks but not at longer times because the median length of hospital stay was 18.5 days. Our findings regarding IGF-1 were consistent with those of previous studies that had smaller cohort sizes [8,12,16,35]. In an earlier study, RBP exhibited little or no change over 10–16 days of nutritional support, as its range of values was much smaller than that of IGF-1 [8]. Interestingly, once the sample size was large enough to perform statistical analysis (i.e., in our study), both RBP and Scr levels were found to change

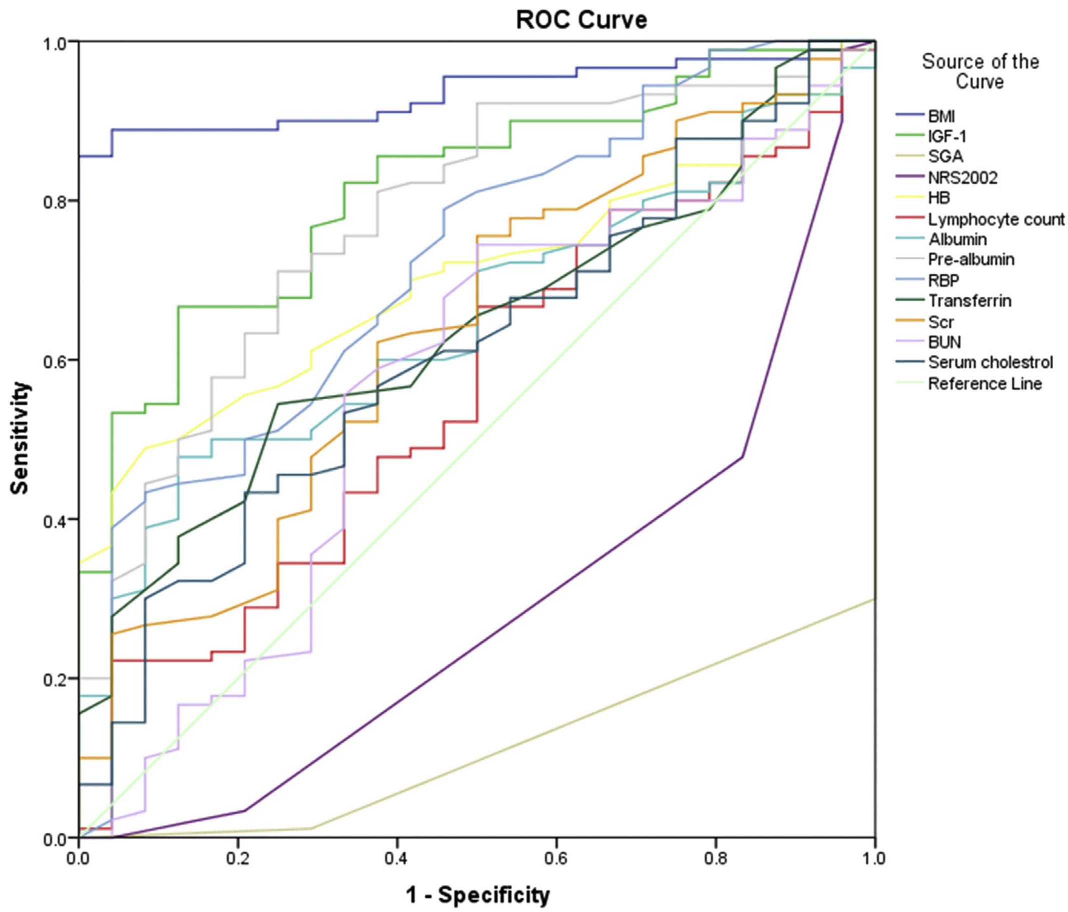

Fig. 3. Receiver operating characteristic (ROC) curve for diagnosing malnutrition. BMI, Body mass index; IGF-1, Insulin-like growth factor-1; SGA, Subjective Global Assessment of nutritional status method; HB, Hemoglobin; RBP, Retinol conjugated protein; Scr, Serum creatinine; BUN, Blood urea nitrogen.

significantly with time. The relatively short half-life of IGF-1 (10–16 h), Scr (4 h) and RBP (12 h) might explain their superior clinical sensitivity [9].

Table 2
The area under the curve of variables for diagnosing malnutrition.

Test Variable	Area	P	95% Confidence Interval	
			Lower Bound	Upper Bound
BMI	0.936	<0.001	0.892	0.979
IGF-1	0.815	<0.001	0.730	0.901
SGA	0.888	<0.001	0.829	0.947
NRS2002	0.710	0.002	0.592	0.828
HB	0.706	0.002	0.609	0.802
Lymphocyte count	0.558	0.381	0.433	0.684
Albumin	0.651	0.023	0.543	0.758
Pre-albumin	0.780	<0.001	0.680	0.881
RBP	0.721	0.001	0.607	0.835
Transferrin	0.638	0.039	0.526	0.749
Scr	0.636	0.041	0.513	0.759
BUN	0.568	0.305	0.432	0.704
Serum cholesterol	0.611	0.095	0.491	0.731

BMI, Body mass index; IGF-1, Insulin-like growth factor-1; SGA, Subjective Global Assessment of nutritional status method; HB, Hemoglobin; RBP, Retinol conjugated protein; Scr, Serum creatinine; BUN, Blood urea nitrogen.

Increased lean body mass parameters such like FFM and SMM are correlated with reduced complications and enhanced recovery than visceral fat levels [36]. To further evaluate the role of IGF-1, we investigated its correlation with lean body mass and found that IGF-1 was an independent predictive factor of FFM, SMM, and whole protein mass, all of which can influence clinical outcomes [37,38]. Consistent with previous research, these results suggested that the elevated IGF-1 levels precede the changes to lean body mass, and that a rise in IGF-1 level may predict increased lean body mass and the amelioration of clinical outcomes [12,39].

Our results showed that BMI, SGA, IGF-1, NRS2002, albumin, pre-albumin, RBP, transferrin, and Scr were associated with nutritional assessment; IGF-1, RBP, and Scr were related to nutritional monitoring; and IGF-1 and BMI were correlated with lean body mass. The overlap analysis based on the aforementioned findings shows that only IGF-1 overlaps in all 3 of these categories (Fig. 5). The results also indicated that IGF-1 could be used to tailor nutritional rehabilitation in adult patients with CIF. Further studies may be needed to investigate the nutritional support factors influencing the changes of IGF-1 to optimal the nutritional support regimens as IGF-1 has more sensitive response to nutritional support. However, our cohort was still relatively small as the lower morbidity of CIF, which limited the reliability of our conclusions. Therefore, further large-cohort

Table 3
The repeated measures analysis for serum nutritional indicators within 2 weeks.

Test Variable	Baseline	Week 1	Week 2	Greenhouse-Geisser	p
IGF-1	85.92 ± 65.54	131.95 ± 89.14	164.61 ± 114.83	32.17	<0.001
Hemoglobin	106.72 ± 21.19	103.97 ± 20.28	104.89 ± 18.98	2.04	0.14
Lymphocyte count	17.22 ± 15.99	14.11 ± 13.21	14.30 ± 13.22	9.31	<0.001
Albumin	36.98 ± 5.53	38.48 ± 4.47	38.85 ± 4.67	7.01	0.003
Pre-albumin	169.28 ± 80.50	167.33 ± 69.87	185.10 ± 78.28	3.50	0.039
RBP	34.04 ± 19.43	33.76 ± 17.61	38.75 ± 20.68	7.42	0.001
Transferrin	2.52 ± 0.81	2.50 ± 1.36	2.85 ± 3.41	0.92	0.36
Scr	60.60 ± 43.16	51.46 ± 31.06	48.88 ± 28.03	17.18	<0.001
BUN	5.78 ± 4.19	6.96 ± 10.68	7.22 ± 10.32	1.616	0.21
Serum cholesterol	3.32 ± 1.24	3.27 ± 0.97	3.39 ± 1.01	0.83	0.41

IGF-1, Insulin-like growth factor-1; RBP, Retinol conjugated protein; Scr, Serum creatinine; BUN, Blood urea nitrogen.

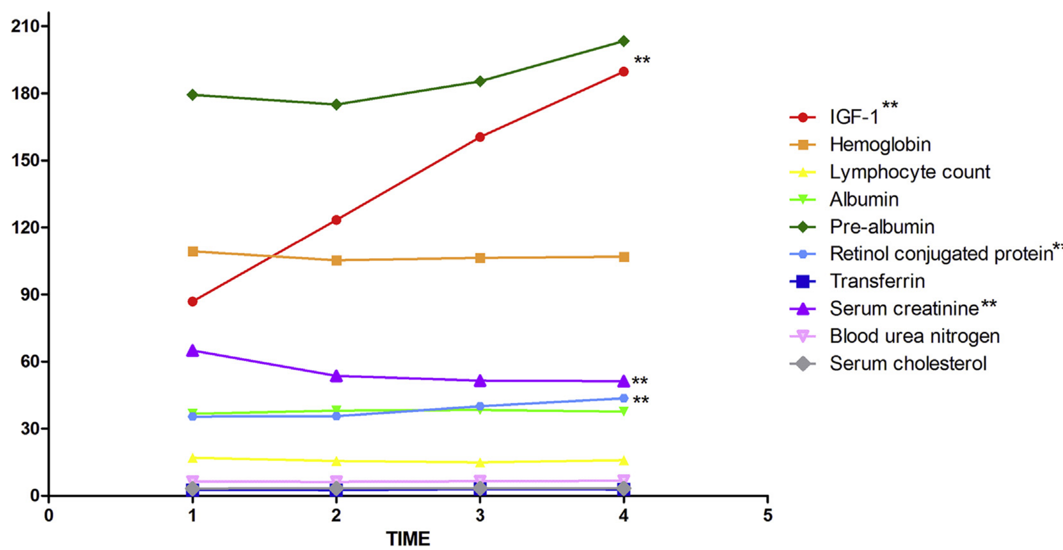

Fig. 4. The repeated measures analysis. IGF-1, RBP and Scr among 4 time points (baseline, week 1, week 2 and week 3) within 3 weeks after admission were significantly different over this period. **, $p < 0.01$; IGF-1, Insulin-like growth factor-1.

Table 4
The bivariate linear correlation or rank correlation analysis.

Parameter		Sex[a,b]	Age	Disease category[a]	BMI	SGA[a]	NRS2002[a]	Malnutrition[a]
FFM	r	−0.333**	0.219**	−0.140	0.402**	−0.238*	−0.014	−0.251**
SMM	r	−0.353**	0.182*	−0.133	0.420**	−0.292**	−0.067	−0.272**
Protein	r	−0.352**	0.182*	−0.137	0.410**	−0.283**	−0.061	−0.265**

Parameter		IGF-1	HB	LC	ALB	Pre-ALB	RBP	Transferrin	Scr	BUN	Cholesterol
FFM	r	0.222**	0.075	−0.095	−0.054	0.179*	0.205*	−0.027	0.238**	0.086	−0.076
SMM	r	0.272**	0.122	−0.065	0.007	0.231**	0.235**	0.030	0.234**	0.103	−0.038
Protein	r	0.270**	0.117	−0.069	0.004	0.225**	0.226**	0.025	0.233**	0.103	−0.045

*, $p < 0.05$; **, $p < 0.01$.
BMI, Body mass index; SGA, Subjective Global Assessment of nutritional status method.
IGF-1, Insulin-like growth factor-1; HB, Hemoglobin; LC, Lymphocyte count; ALB, Albumin; Pre-Alb, Pre-albumin; RBP, Retinol conjugated protein; Scr, Serum creatinine; BUN, Blood urea nitrogen.
[a] Spearman rank correlation.
[b] Males as reference.

Table 5
Multivariate linear regression analysis for fat free mass.

Variable	Unstandardized Coefficients		t	p
	β	SE		
(Constant)	11.928	9.016	1.323	0.189
Sex	−1.910	1.648	−1.159	0.249
Age	0.104	0.055	1.884	0.062
BMI	0.953	0.329	2.900	0.005
SGA	0.171	1.605	0.107	0.915
Malnutrition	4.770	2.767	1.724	0.088
IGF-1	0.041	0.018	2.221	0.029
Pre-albumin	−0.019	0.015	−1.244	0.216
RBP	0.072	0.055	1.321	0.189
Scr	0.028	0.027	1.067	0.288

BMI, Body mass index; SGA, Subjective Global Assessment of nutritional status method; IGF-1, Insulin-like growth factor-1; RBP, Retinol conjugated protein; Scr, Serum creatinine.

Table 6
Multivariate linear regression analysis for skeletal muscle mass.

Variable	Unstandardized Coefficients		t	p
	β	SE		
(Constant)	4.760	5.275	0.902	0.369
Sex	−1.250	0.962	−1.299	0.197
Age	0.054	0.032	1.681	0.096
BMI	0.593	0.192	3.085	0.003
SGA	−0.231	0.939	−0.246	0.806
Malnutrition	3.022	1.620	1.866	0.065
IGF-1	0.024	0.011	2.267	0.025
Pre-albumin	−0.010	0.009	−1.120	0.265
RBP	0.048	0.032	1.519	0.132
Scr	0.017	0.016	1.060	0.292

BMI, Body mass index; SGA, Subjective Global Assessment of nutritional status method; IGF-1, Insulin-like growth factor-1; RBP, Retinol conjugated protein; Scr, Serum creatinine.

Table 7
Multivariate linear regression analysis for body protein mass.

Variable	Unstandardized Coefficients		t	p
	β	SE		
(Constant)	2.155	1.776	1.214	0.228
Sex	−0.398	0.324	−1.230	0.221
Age	0.018	0.011	1.685	0.095
BMI	0.195	0.065	3.019	0.003
SGA	−0.059	0.316	−0.185	0.853
Malnutrition	1.024	0.545	1.878	0.063
IGF-1	0.008	0.004	2.261	0.026
Pre-albumin	−0.003	0.003	−1.121	0.265
RBP	0.016	0.011	1.477	0.143
Scr	0.006	0.005	1.051	0.296

BMI, Body mass index; SGA, Subjective Global Assessment of nutritional status method; IGF-1, Insulin-like growth factor-1; RBP, Retinol conjugated protein; Scr, Serum creatinine.

clinical trials are required to confirm the usefulness of IGF-1 in nutritional monitoring among patients with CIF.

In conclusion, serum IGF-1 is associated with the traditional nutrition assessment index and is of greater value in diagnosing malnutrition. Moreover, IGF-1 showed superiority to other nutritional indicators in monitoring short-term changes to nutritional status or in evaluating the efficiency of nutritional support in CIF patients; this is likely owing to its shorter half-life, more sensitive response, and correlation with lean body mass.

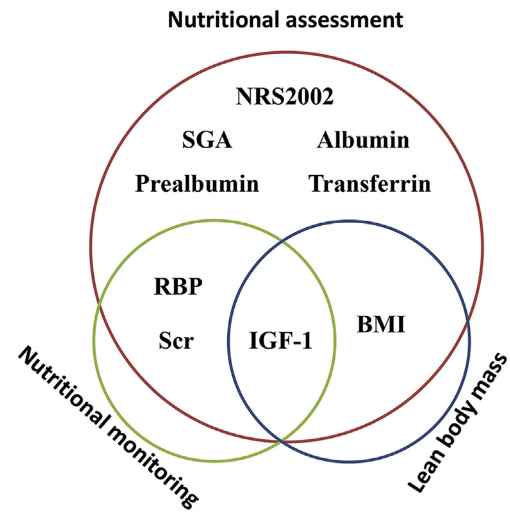

Fig. 5. The Venn diagram. IGF-1 was correlated with nutritional assessment, nutritional monitor and lean body mass; BMI was correlated with nutritional assessment and lean body mass; RBP and Scr were correlated with nutritional assessment and nutritional monitor; albumin, pre-albumin and transferrin were only correlated with nutritional assessment respectively. BMI, Body mass index; IGF-1, Insulin-like growth factor-1; RBP, Retinol conjugated protein; Scr, Serum creatinine.

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Author contributions

WXY, LJS and TF designed research (project conception, development of overall research plan, and study oversight); TF, SHF, GXJ and ZL conducted research (hands-on conduct of the experiments and data collection); HYC, CPX, SRT and LST provided databases of body composition; TF, WXY, GXJ and ZL analyzed data or performed statistical analysis; TF and SHF wrote paper (only authors who made a major contribution); WXY had primary responsibility for final content.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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