Observational Study

Medicine

OPEN

Neutrophil-lymphocyte ratio as a risk factor for osteoporotic vertebrae fractures and femoral neck fractures

Hao Zhu, MD[a], Zheng Li, MD[a], Yizhai Zhou, MD[a], Rugeng Zheng, MD[a], Cong Diao[b], Kepeng Li, MD[a,*], Qi Feng, MD[c,*]

Abstract

Fracture is associated with osteopenia after osteoporosis. Neutrophil-lymphocyte ratio (NLR) is common in inflammatory diseases. NLR can be used as an effective clinical tool to assess postmenopausal osteoporosis. The aim of this study is to further explore the relationship between elevated NLR and the severity of osteoporotic vertebrae fractures and femoral neck fracture based on magnetic resonance imaging (MRI). A total of 80 patients with osteoporotic vertebrae fractures, osteoporotic femoral neck fracture in Baoding Second Central Hospital from 2017 to 2020 were selected as the research objects. This study included a series of pretreatment factors, mainly including white blood cell count, red blood cell count, hemoglobin, and the general condition of the patients. Statistical methods included Pearson chi-square test, Spearman correlation test, logistic regression analysis and receiver operator characteristic (ROC) curve. According to Pearson chi-square test, Spearman correlation test, univariate/multivariate logistic regression analysis, the severity of osteoporotic vertebrae fractures, osteoporotic femoral neck fracture was significantly correlated with NLR ($P < .001$). NLR (odds ratio [OR] = 13.229, 95% CI: 4.167–41.998, $P < .001$) was a significant independent risk factor for osteoporotic vertebrae fractures, osteoporotic femoral neck fracture. receiver operator characteristic (ROC) curve was used to detect the specificity and sensitivity. The level of NLR has an important influence on the severity of osteoporotic vertebrae fractures and femoral neck fracture. The higher the level of NLR, the more serious the osteoporotic vertebrae fractures and femoral neck fracture.

Abbreviations: AUC = area under the curve, BMD = bone mineral density, CI = confidence interval, MRI = magnetic resonance imaging, NLR = neutrophil-lymphocyte ratio, OR = odds ratio, ROC = receiver operator characteristic.

Keywords: femoral neck fractures, inflammation, magnetic resonance imaging, neutrophil-lymphocyte ratio, osteoporosis, osteoporotic vertebrae fractures

1. Introduction

Osteoporotic vertebral fracture is a common fragility fracture.[1] After fracture, severe back pain and mobility disorders will occur. The choice of treatment is usually general, surgical, or conservative.[2] Femoral neck fracture is a common acute injury,[3] which is caused by direct or indirect violence below the femoral head and above the base of the femoral neck.[4] The occurrence of femoral neck fracture is associated with osteopenia after osteoporosis.[5] Osteoporosis is a kind of metabolic bone disease characterized by bone mass reduction, abnormal bone microstructure and easy fracture. It is also a degenerative disease. The main reason is that bone synthesis decreases, decomposition increases, and intestinal calcium absorption decreases in the elderly. Disturbance of calcium metabolism is also an important factor. In addition, reduced muscle activity, lack of muscle stimulation of bones, and reduced osteoblast activity can also cause osteoporosis for various reasons.[6–8] However, the relationship between osteoporotic vertebrae fractures, osteoporotic femoral neck fracture and blood indexes and humoral immune factors remains unclear.

The first examination method of choice for osteoporotic vertebrae fractures, femoral neck fracture is usually X-ray film,

The research was funded by social development project of Baoding City (Title: Effectiveness and safety of different combined drug regiments in the treatment of vertebral osteoporotic fractures, No: 20200511).

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

This study was approved by the Ethics Committee of Baoding Second Central Hospital. Written informed consent was obtained from all patients.

[a] Department of Orthopedics, The Second Central Hospital of Baoding, Zhuozhou City, Hebei Province, PR China, [b] Obstetrics Department, The Second Central Hospital of Baoding, Zhuozhou City, Hebei Province, PR China, [c] Department of Orthopedics, The Fourth Hospital of Hebei Medical University, Shijiazhuang, Hebei, PR China.

** Correspondence: Kepeng Li, Department of Orthopedics, The Second Central Hospital of Baoding, No. 57 Fanyang Zhong Road, Zhuozhou City, Hebei Province, 072750, PR China (e-mail: likepeng575@163.com) and Qi Feng, Department of Orthopedics, The Fourth Hospital of Hebei Medical University, 12 Health Road, Shijiazhuang, Hebei 050011, PR China (e-mail: qfq1232021@163.com).*

How to cite this article: Zhu H, Li Z, Zhou Y, Zheng R, Diao C, Li K, Feng Q. Neutrophil-lymphocyte ratio as a risk factor for osteoporotic vertebrae fractures and femoral neck fractures. Medicine 2022;101:48(e32125).

Received: 16 September 2022 / Received in final form: 9 November 2022 / Accepted: 10 November 2022

http://dx.doi.org/10.1097/MD.0000000000032125

so as to determine whether there is interruption of continuity. However, many fractures are not obvious and may not be visible on regular X-rays. Magnetic resonance imaging (MRI) is widely used as a noninvasive tool to detect, characterize, assess response to treatment, and follow up lesions.[9] MRI can provide 3-dimensional (3D) images with high spatial resolution, high penetration and high contrast without adverse effects on the body.[10] Therefore, MRI has great potential superiority in the diagnosis of diseases.

Neutrophil-lymphocyte ratio (NLR) is the ratio of neutrophil to lymphocyte count. NLR is a simple, economical and easily available biomarker, which is commonly used in various malignant tumors and inflammatory diseases.[11,12] On the one hand, inflammation leads to primary disease; on the other hand, it will affect the skeletal system and interfere with bone metabolism, and inflammation plays a very important role in the occurrence and development of osteoporosis. No matter what causes osteoporosis, it will inevitably lead to systemic or focal inflammatory response, thereby promoting the occurrence and development of osteoporosis. Regarding the relationship between NLR and osteoporosis, studies have reported that NLR and PLR are associated with decreased bone mineral density (BMD) and osteoporosis.[13,14] Huang et al confirmed that NLR level is closely related to BMD in postmenopausal women without diabetes, suggesting that NLR can be used as an effective clinical tool to assess postmenopausal osteoporosis.[15] Inflammation has an effect on fracture repair.[16] NLR has been suggested as an inflammatory marker in various diseases. Osteoporotic vertebrae fractures and femoral neck fractures create a significant inflammatory burden. Therefore, it is logical to study NLR in patients with fractures. Relevant studies have shown that mean platelet volume to lymphocyte ratio can be used as a new marker of diabetic nephropathy.[17] Mean platelet volume is a precursor of malignant thyroid nodules.[18] NLR increased in Hashimoto's thyroiditis diagnosis.[19] NLR was used as an indicator of type 2 diabetes control level.[20]

Therefore, this study intends to explore and verify the relationship between elevated NLR and the incidence of osteoporotic vertebrae fractures and femoral neck fractures based on MRI by Pearson chi-square test, Spearman correlation analysis, univariate and multivariate logistic regression analysis, receiver operator characteristic (ROC) curve and other methods. This study will provide a new direction for the diagnosis and treatment of osteoporotic vertebrae fractures and femoral neck fractures.

2. Methods

2.1. Patients and groups

The subjects were 80 patients with osteoporotic vertebrae fractures and femoral neck fractures caused by osteoporosis in a prospective study conducted in Baoding Second Central Hospital from 2017 to 2020. All patients were divided into 2 groups according to the severity of fracture: mild group and severe group. Then, the clinical data were analyzed to explore the sensitivity and specificity of NLR for femoral neck fractures based on MRI.

2.2. Ethics and patient consent

This study was approved by the Ethics Committee of Baoding Second Central Hospital. Written informed consent was obtained from all patients.

2.3. Inclusion and exclusion criteria

Inclusion criteria: 40 to 90 years old. Patients with no history of surgery and a diagnosis of osteoporotic vertebrae fractures and femoral neck fractures.

Exclusion criteria: age <40 years or >90 years. Patients with poor lung function and heart function. Patients requiring emergency orthopedic surgery.

2.4. Collection of clinical indicators

The sex, age and other basic information of the patients were recorded in detail. In addition, the relevant clinical parameters were compared between the 2 groups.

2.5. Statistics

Data are presented as percentages and percentages of the total. Kolmogorov–Smirnov test was used for the normality analysis. Pearson chi-square test was used to analyze the correlation between clinical parameters and the severity of fracture. Spearman correlation analysis was used to compare the correlation between clinical data and fracture. Univariate and multivariate logistic regression analysis were used to calculate the odds ratio (OR) value of fracture. ROC curve was used to compare the area under the curve (AUC) of each related factor, and to analyze the relationship between NLR and the severity of fracture. All statistical analyses were performed using SPSS software version 21.0 (IBM Corporation, Armonk, NY). $P < .05$ was assumed to be statistically significant.

3. Results

3.1. The correlation between clinical parameters and fracture was tested by χ^2 test

The relationship between potential postoperative parameters and the severity of osteoporotic vertebrae fractures and femoral neck fractures was summarized according to Pearson chi-square test. In individuals, NLR ($P < .001$) was significantly associated with the severity of osteoporotic vertebrae fractures and femoral neck fractures. However, sex ($P = .779$), age ($P = .332$), white blood cell count ($P = .684$), red blood cell count ($P = .491$), hemoglobin ($P = .558$), basophil count ($P = .610$), and immature monocyte count ($P = .610$) were not significantly associated with osteoporotic vertebrae fractures and femoral neck fractures (Table 1).

3.2. Spearman correlation tests for further association of latent characteristics with fracture

To confirm whether potentially relevant characteristics of osteoporotic patients have a significant effect on osteoporotic vertebrae fractures and femoral neck fractures, further correlation analyses were performed. Spearman correlation coefficient showed that osteoporotic vertebrae fractures and femoral neck fractures was significantly correlated with NLR ($\rho = 0.540$, $P < .001$). However, sex ($\rho = 0.031$, $P = .782$), age ($\rho = 0.108$, $P = .338$), white blood cell count ($\rho = 0.046$, $P = .688$), red blood cell count ($\rho = -0.077$, $P = .497$), hemoglobin ($\rho = -0.066$, $P = .564$), basophilic count ($\rho = 0.057$, $P = .615$), immature monocytes ($\rho = 0.057$, $P = .615$) were not significantly associated with osteoporotic vertebrae fractures and femoral neck fractures (Table 2).

3.3. Univariate logistic regression proportional risk analysis of the related factors of fracture

In addition, univariate logistic regression was used to analyze the correlation between relevant parameters and the severity of osteoporotic vertebrae fractures and femoral neck fractures, OR and 95% confidence interval (CI), so as to further determine the related factors and risk groups of osteoporotic vertebrae

Table 1

Relevant characteristics of patients with femoral neck fracture.

Characteristics			Femoral neck fractures		P
			Mild (%)	Severe (%)	
Sex	Male	32	19 (23.8%)	13 (16.3%)	.779
	Female	48	30 (37.5%)	18 (22.5%)	
Age	≤65	39	26 (32.5%)	13 (16.3%)	.332
	>65	41	23 (28.8%)	18 (22.5%)	
White blood cell count	Low	41	26 (32.5%)	15 (18.8%)	.684
	High	39	23 (28.8%)	16 (20.0%)	
Red blood cell count	Low	40	23 (28.8%)	17 (21.3%)	.491
	High	40	26 (32.5%)	14 (17.5%)	
Hemoglobin	Low	38	22 (27.5%)	16 (20.0%)	.558
	High	42	27 (33.8%)	15 (18.8%)	
NLR*	Low	45	38 (47.5%)	7 (8.8%)	<.001*
	High	35	11 (13.8%)	24 (30.0%)	
Basophil count	Low	39	25 (31.3%)	14 (17.5%)	.610
	High	41	24 (30.0%)	17 (21.3%)	
Immature monocyte count	Low	39	25 (31.3%)	14 (17.5%)	.610
	High	41	24 (30.0%)	17 (21.3%)	

Pearson chi-square test.
NLR = neutrophil-lymphocyte ratio.
* $P < .05$.

Table 2

Relationship between characteristics of patients with femoral neck fracture and femoral neck fracture.

Characteristics	Femoral neck fractures	
	ρ	P
Sex	−0.031	.782
Age	0.108	.338
White blood cell count	0.046	.688
Red blood cell count	−0.077	.497
Hemoglobin	−0.066	.564
NLR*	0.540	<.001*
Basophil count	0.057	.615
Immature monocyte count	0.057	.615

Spearman correlation test.
NLR = neutrophil-lymphocyte ratio.
* $P < .05$.

fractures and femoral neck fractures. Table 3 showed that NLR (OR = 11.844, 95% CI: 4.036–34.760, $P < .001$) was significantly correlated with the severity of osteoporotic vertebrae fractures and femoral neck fractures. However, sex (OR = 0.877, 95% CI: 0.351–2.192, $P = .779$), age (OR = 1.565, 95% CI: 0.632–3.879, $P = .333$), white blood cell count (OR = 1.206, 95% CI: 0.490–2.967,$P = .684$), red blood cell count (OR = 0.729, 95% CI: 0.295–1.797, $P = .492$), hemoglobin (OR = 0.764, 95% CI: 0.310–1.882, $P = .558$), basophil count (OR = 1.265, 95% CI: 0.513–3.118, $P = .610$) and immature monocyte count (OR = 1.265, 95% CI: 0.513–3.118, $P = .610$) were not significantly associated with the severity of osteoporotic vertebrae fractures and femoral neck fractures (Table 3).

3.4. Multivariate logistic regression analysis of the related factors of fracture

Multivariate logistic regression was used to describe the OR and 95% CI at the multivariable level of the study subjects. At the level of multiple logistic regression, NLR (OR = 13.229, 95% CI: 4.167–41.998, $P < .001$) was significantly associated with osteoporotic vertebrae fractures and femoral neck fractures, sex (OR = 0.912, 95% CI: 0.271–3.062, $P = .881$), age (OR = 2.275, 95% CI: 0.690–7.504, $P = .177$), white blood cell count (OR = 1.751, 95% CI: 0.492–6.239, $P = .387$) and red blood cell count (OR = 0.610, 95% CI: 0.173–2.153, $P = .177$). $P = .443$), hemoglobin (OR = 1.120, 95% CI: 0.294–4.265, $P = .868$), basophil count (OR = 1.469, 95% CI: 0.399–5.412, $P = .563$) and immature monocytes (OR = 0.837, 95% CI: 0.254–2.752, $P = .769$) had no significant correlation with osteoporotic vertebrae fractures and femoral neck fractures (Table 4).

3.5. ROC analysis

ROC curves were constructed to determine the influence of patient-related parameters on femoral neck fracture, and AUC was used to determine the confidence: NLR (AUC = 0.775, $P < .001$) (Fig. 1).

3.6. Prevalence of patients based on NLR expression level

Based on MRI, patients with osteoporotic vertebrae fractures and femoral neck fractures tend to have mild symptoms when NLR is low. The higher the NLR, the more severe the osteoporotic vertebrae fractures and femoral neck fractures (Fig. 2).

4. Discussion

Our study suggests that the incidence of osteoporotic vertebrae fractures and femoral neck fractures in osteoporosis patients is closely related to NLR based on MRI. According to Pearson chi-square test, Spearman correlation analysis, univariate and multivariate logistic regression analysis and ROC curve analysis, the higher the NLR, the higher the incidence of osteoporotic vertebrae fractures and femoral neck fractures.

NLR is the ratio of neutrophil to lymphocyte counts. The increase of neutrophils in peripheral blood indicates the presence of acute inflammation in the body, and the decrease of lymphocytes decreases the immune defense ability of the body. Therefore, NLR can directly reflect the acute inflammation and immune defense status of the body. In recent years, some progress has been made in the predictive value of NLR. Numerous studies have shown that increased NLR is closely related to disease severity and prognosis. Forget et al reported that NLR >0.05, 5 days after hip fracture surgery was associated with a higher risk of death.[21] Temiz and

Table 3

Univariate logistic proportional regression analysis of the influence of relevant parameters on femoral neck fracture.

Characteristics		Femoral neck fractures		
		OR	95% CI	*P*
Sex	Male	1		.779
	Female	0.877	0.351–2.192	
Age	≤65	1		.333
	>65	1.565	0.632–3.879	
White blood cell count	Low	1		.684
	High	1.206	0.490–2.967	
Red blood cell count	Low	1		.492
	High	0.729	0.295–1.797	
Hemoglobin	Low	1		.558
	High	0.764	0.310–1.882	
NLR *	Low	1		<.001*
	High	11.844	4.036–34.760	
Basophil count	Low	1		.610
	High	1.265	0.513–3.118	
Immature monocyte count	Low	1		.610
	High	1.265	0.513–3.118	

CI = confidence interval, NLR = neutrophil-lymphocyte ratio, OR = odds ratio.
* $P < .05$.

Table 4

Multivariate logistic proportional regression analysis of the characteristics of femoral neck fractures and their effects.

Characteristics	Femoral neck fractures		
	OR	95% CI	*P*
Sex	0.912	0.271–3.062	.881
Age	2.275	0.690–7.504	.177
White blood cell count	1.751	0.492–6.239	.387
Red blood cell count	0.610	0.173–2.153	.443
Hemoglobin	1.120	0.294–4.265	.868
NLR*	13.229	4.167–41.998	<.001*
Basophil count	1.469	0.399–5.412	.563
Immature monocyte count	0.837	0.254–2.752	.769

CI = confidence interval, NLR = neutrophil-lymphocyte ratio, OR = odds ratio.
* $P < 0.05$.

Ersozlu noted that postoperative NLR ≥4.7 was associated with an increased risk of death in patients with fracture.[22] Other study have shown that NLR is superior to leukocyte and neutrophil counts in predicting adverse outcomes in cardiovascular patients and malignant tumor diseases.[23]

However, inflammation is one of the most important responses in the development of osteoporosis. Whatever the cause of osteoporosis, there must be a systemic or local inflammatory response.

The inflammatory response in the body will enhance the viability of osteoclasts and lead to increased bone resorption, thereby accelerating the process of osteoporosis. All these theories suggest the importance of inflammatory response in osteoporosis. In addition, a large number of studies have proved that NLR index plays a very important role in fracture. In a study of 438 patients, BMD at the lumbar spine and femoral neck decreased with increasing NLR.[24] Increased NLR after hip fracture is reported to be a risk factor for postoperative mortality and cardiovascular complications.[21] Atlas et al found that patients in the intensive care unit ($P = .007$) and those who died ($P = .007$) had higher NLR on day 5 after hip fracture surgery.[25] The NLR of discharged patients was similar to that of patients who died before surgery, and the NLR level of patients who died after surgery was higher ($P = .007$).

The occurrence of osteoporotic vertebrae fractures and femoral neck fractures is associated with osteopenia after osteoporosis. Osteoporosis can lead to increased trabecular space and decreased bone strength. In addition, there are many trophoblast pores in the upper part of the femoral neck, which reduce the strength of the femoral neck; therefore, the femoral neck is prone to fragility fractures.[26] In addition, the elderly are often accompanied by a variety of underlying diseases, such as diabetes, hypertension and cardiovascular and cerebrovascular diseases, which can lead to coma and falls in the elderly and femoral neck fractures. Zeynel et al[14] proved that the serum NLR of elderly patients with osteoporosis is much higher than that of non-osteoporosis patients, and NLR is an independent variable for predicting the occurrence of osteoporosis. Therefore, we believe that NLR can predict the incidence of femoral neck fracture in osteoporosis patients by reflecting inflammatory factors.

MRI is an imaging technology that uses the signal generated by the resonance of the nuclear nucleus in a strong magnetic field to reconstruct the image, which belongs to a nuclear physical phenomenon.[27] MRI has the unique advantages of no radiation damage, no bone artifacts, multi-dimensional and multi-parameter imaging, high soft tissue discrimination ability, and no need to use contrast media to display vascular structure. It is another important development in the field of medical imaging.[28] MRI is not only more informative than many other imaging techniques in medical imaging, but also different from existing imaging techniques. The use of MRI to image the internal structure of the human body will lead to a revolutionary medical diagnostic tool. The application of the rapidly changing gradient magnetic field has greatly accelerated the speed of MRI, made the application of this technology in clinical diagnosis and scientific research become a reality, and greatly promoted the rapid development of medicine, neurophysiology and cognitive neuroscience.[29,30] Therefore, based on MRI, this study investigated the NLR as a risk factor for osteoporotic vertebrae fractures and femoral neck fractures.

Our study has some limitations. The study had a small sample of data and the results are subject to error. In future studies, we will recruit more subjects to verify the role of NLR in osteoporotic vertebrae fractures and femoral neck fractures.

5. Conclusion

In conclusion, this study confirmed that NLR index plays a crucial role in the incidence of osteoporotic vertebrae fractures and femoral neck fractures in patients with osteoporosis based on

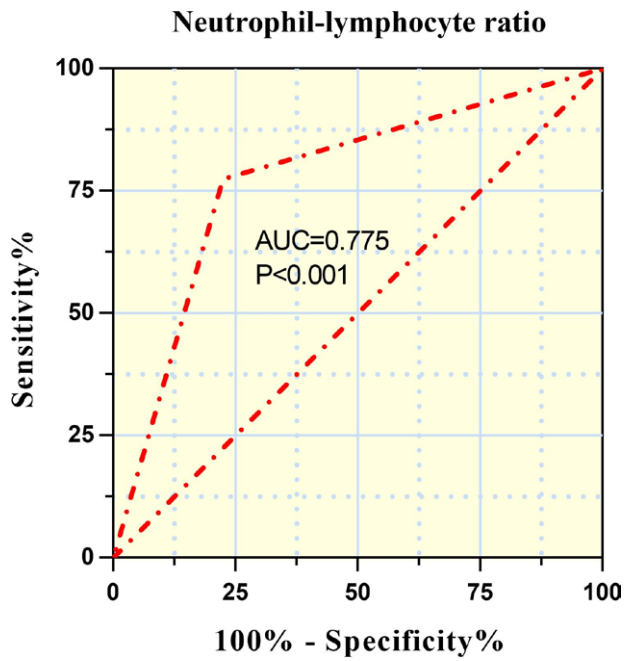

Figure 1. ROC curve of neutrophil-lymphocyte ratio in patients with femoral neck fracture. ROC = receiver operator characteristic.

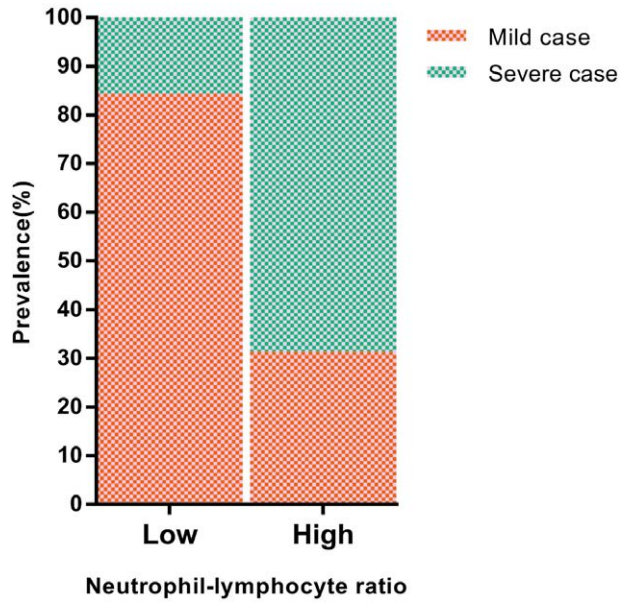

Figure 2. Prevalence of patients based on NLR expression levels. NLR = neutrophil-lymphocyte ratio.

MRI, with higher NLR being associated with higher incidence of osteoporotic vertebrae fractures and femoral neck fractures. This finding provides a new idea for the diagnosis and treatment of osteoporotic vertebrae fractures and femoral neck fractures.

Author contributions

Conceptualization: Zheng Li, Qi Feng.
Data curation: Hao Zhu, Yizhai Zhou, Cong Diao, Kepeng Li.
Formal analysis: Zheng Li, Qi Feng.
Methodology: Hao Zhu, Yizhai Zhou, Cong Diao.
Project administration: Rugeng Zheng, Qi Feng.
Software: Yizhai Zhou, Rugeng Zheng, Cong Diao.
Supervision: Rugeng Zheng.
Writing – original draft: Hao Zhu, Kepeng Li.
Writing – review & editing: Zheng Li, Cong Diao, Qi Feng.

References

[1] Capdevila-Reniu A, Navarro-López M, López-Soto A. Osteoporotic vertebral fractures: a diagnostic challenge in the 21(st) century. Rev Clin Esp (Barc). 2021;221:118–24.
[2] Prost S, Pesenti S, Fuentes S, et al. Treatment of osteoporotic vertebral fractures. Orthop Traumatol Surg Res. 2021;107:102779.
[3] Patterson JT, Tangtiphaiboontana J, Pandya NK. Management of pediatric femoral neck fracture. J Am Acad Orthop Surg. 2018;26:411–9.
[4] Florschutz AV, Langford JR, Haidukewych GJ, et al. Femoral neck fractures: current management. J Orthop Trauma. 2015;29:121–9.
[5] Oka R, Ohira M, Suzuki S, et al. Fracture risk assessment tool (FRAX) and for the diagnosis of osteoporosis in Japanese middle-aged and elderly women: Chiba bone survey. Endocr J. 2018;65:193–202.
[6] Miller PD. Management of severe osteoporosis. Expert Opin Pharmacother. 2016;17:473–88.
[7] Baccaro LF, Conde DM, Costa-Paiva L, et al. The epidemiology and management of postmenopausal osteoporosis: a viewpoint from Brazil. Clin Interv Aging. 2015;10:583–91.
[8] Zhu S, He H, Zhang C, et al. Effects of pulsed electromagnetic fields on postmenopausal osteoporosis. Bioelectromagnetics. 2017;38:406–24.
[9] Cannella R, Sartoris R, Grégory J, et al. Quantitative magnetic resonance imaging for focal liver lesions: bridging the gap between research and clinical practice. Br J Radiol. 2021;94:20210220202102220.
[10] Jakab A, Payette K, Mazzone L, et al. Emerging magnetic resonance imaging techniques in open spina bifida in utero. Eur Radiol Exp. 2021;5:23.
[11] Pirozzolo G, Gisbertz SS, Castoro C, et al. Neutrophil-to-lymphocyte ratio as prognostic marker in esophageal cancer: a systematic review and meta-analysis. J Thorac Dis. 2019;11:3136–45.
[12] Afari ME, Bhat T. Neutrophil to lymphocyte ratio (NLR) and cardiovascular diseases: an update. Expert Rev Cardiovasc Ther. 2016;14:573–7.
[13] Koseoglu SB. Bone loss & platelet-to-lymphocyte ratio. Biomark Med. 2017;11:5–10.
[14] Öztürk ZA, Yesil Y, Kuyumcu ME, et al. Inverse relationship between neutrophil lymphocyte ratio (NLR) and bone mineral density (BMD) in elderly people. Arch Gerontol Geriatr. 2013;57:81–5.
[15] Huang C, Li S. Association of blood neutrophil lymphocyte ratio in the patients with postmenopausal osteoporosis. Pak J Med Sci. 2016;32:762–5.
[16] Goodnough LH, Goodman SB. Relationship of aging, inflammation, and skeletal stem cells and their effects on fracture repair. Curr Osteoporos Rep. 2022;20:320–5.
[17] Kocak MZ, Aktas G, Erkus E, et al. Mean platelet volume to lymphocyte ratio as a novel marker for diabetic nephropathy. J Coll Physicians Surg Pak. 2018;28:844–7.
[18] Sit M, Aktas G, Ozer B, et al. Mean platelet volume: an overlooked herald of malignant thyroid nodules. Acta Clin Croat. 2019;58:417–20.
[19] Aktas G, Sit M, Dikbas O, et al. Elevated neutrophil-to-lymphocyte ratio in the diagnosis of Hashimoto's thyroiditis. Rev Assoc Med Bras (1992). 2017;63:1065–8.
[20] Duman TT, Aktas G, Atak BM, et al. Neutrophil to lymphocyte ratio as an indicative of diabetic control level in type 2 diabetes mellitus. Afr Health Sci. 2019;19:1602–6.
[21] Forget P, Moreau N, Engel H, et al. The neutrophil-to-lymphocyte ratio (NLR) after surgery for hip fracture (HF). Arch Gerontol Geriatr. 2015;60:366–71.
[22] Temiz A, Ersözlü S. Admission neutrophil-to-lymphocyte ratio and postoperative mortality in elderly patients with hip fracture. Ulus Travma Acil Cerrahi Derg. 2019;25:71–4.
[23] Yardımcı S, Uğurlu MU, Coşkun M, et al. Neutrophil-lymphocyte ratio and mean platelet volume can be a predictor for severity of acute appendicitis. Ulus Travma Acil Cerrahi Derg. 2016;22:163–8.
[24] Yilmaz H, Uyfun M, Yilmaz TS, et al. Neutrophil-lymphocyte ratio may be superior to C-reactive protein for predicting the occurrence of postmenopausal osteoporosis. Endocr Regul. 2014;48:25–33.
[25] Atlas A, Duran E, Pehlivan B, et al. The effect of increased neutrophil lymphocyte ratio on mortality in patients operated on due to hip fracture. Cureus. 2020;12:e6543.
[26] Napoli N, Schwartz AV, Palermo L, et al. Risk factors for subtrochanteric and diaphyseal fractures: the study of osteoporotic fractures. J Clin Endocrinol Metab. 2013;98:659–67.

[27] Jacquier M, Arthuis C, Grévent D, et al. Dynamic contrast enhanced magnetic resonance imaging: a review of its application in the assessment of placental function. Placenta. 2021;114:90–9.
[28] Soni N, Ora M, Bathla G, et al. Multiparametric magnetic resonance imaging and positron emission tomography findings in neurodegenerative diseases: current status and future directions. Neuroradiol J. 2021;34:263–88.
[29] Landelle C, Lungu O, Vahdat S, et al. Investigating the human spinal sensorimotor pathways through functional magnetic resonance imaging. Neuroimage. 2021;245:118684.
[30] Solyanik O, Heimer M. [Clinical impact of abbreviated unenhanced prostate protocols in magnetic resonance imaging]. Radiologe. 2021;61:810–7.