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Esophageal two-phase supine/standing scintigraphy and balloon dilatation in achalasia: 20 years of experience

Dvofazna scintigrafija jednjaka u ležećem/stojećem položaju i balon dilatacija kod ahalazije: 20 godina iskustva

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Abstract

Background/Aim. The most frequent therapeutic method for achalasia is balloon dilatation (BD). Esophageal scintigraphy is potentially the most convenient method for the evaluation of achalasia by quantifying esophageal transit. The aim of this study was to present the results of esophageal scintigraphy (ES) in achalasia treated by BD for a long period of time, from 1997 to 2016, and to set parameters suitable for predicting treatment outcomes. **Methods.** Two-phase ES in anterior projection was performed. The first phase involved swallowing 10 mL of water with 18.5 MBq ^{99m}Tc in a supine position. The second phase was performed in a standing position after swallowing 100 mL of water. The retention index (RI) of esophageal radioactivity was calculated after the imaging using registered esophageal and gastric counts. ES was performed in 52 patients (34 males and 18 females, aged 22–75 years, the median age 44 years) before and after BD. In 31 patients, only two scintigraphies were performed. In the remaining 21 patients, follow-up and repeated scintigraphies were continued including the patients with therapeutic failure and repeated BD. BD was repeated in 8 patients, and those were followed up and evaluated over time. Modified BD was performed with Rigiflex balloon dilators. **Results.** A typical scintigraphic finding in the supine position was passive esophageal filling without the evidence of motility, and in most patients, 43 of them (83%), radionuclide elimination in the stomach was absent. Evaluating values before and long after the first BD, it was shown that certain values of RI indicated remission or relapse of the disease. The RI difference higher than 50% after BD was a reliable indicator of a longer remission. The age and gender of patients had no impact on the outcome of dilatation, but younger patients were with a higher risk of early failure (6 patients during the first year after BD). ES showed that the first BD was initially successful in 50 patients and after the follow-up in 41 (79%) patients. **Conclusion**. A two-phase supine/standing ES is most suitable for diagnosing and the follow-up of achalasia. RI represents an important parameter for the evaluation and prediction of therapeutic response. The RI difference of more than 50% after BD is a reliable predictor of a longer remission. Age and gender have no impact on dilatation outcome, but patients younger than 40 years have a higher risk of early therapeutic failure.

Key words:
balloon dilatation; esophagus; achalasia; prognosis; radionuclide imaging; treatment outcome

Apstrakt

Uvod/Cilj. Najčešća terapijska metoda za ahalaziju je balon dilatacija (BD). Scintigrafija jednjaka je potencijalno najpogodnija metoda za procenu ahalazije kvantifikovanjem ezofagealnog tranzita. Cilj rada je bio da se prikažu rezultati primene scintigrafije jednjaka (SJ) kod bolesnika sa ahalazijom lečenih BD u periodu od 1997. do 2016. godine i pronalaženje parametara pogodnih za predviđanje rezultata lečenja. **Metode**. Dvofazna SJ izvođena je u anteriornoj projekciji. Prva faza je rađena u ležećem položaju gutanjem 10 mL vode sa 18,5 MBq ^{99m}Tc. Druga faza je izvođena u stojećem položaju nakon gutanja 100 mL vode. Posle scintigrafije, izračunavan je indeks retencije (RI) korišćenjem registrovanih impulsa jednjaka i želuca. Kod 52 bolesnika – 34 muškaraca i 18 žena, životne dobi između 22 i 75 godina života, medijana 44 godine, urađena je SJ pre i posle BD. Kod 31 bolesnika urađene su samo po dve scintigrafije. Kod ostalih 21 bolesnika nastavljeni su praćenje i kontrolne scintigrafije, uključujući i bolesnike s neuspehom i ponovljenim BD. Kod 8 bolesnika, koji su dalje praćeni, ponovljena je BD. Modifikovana BD rađena je primenom Rigiflex balon dilatatora. **Rezultati**. Tipičan scintigrafski nalaz u ležećem položaju bio je pasivno ispunjavan

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je jednjaka bez uočljivog motiliteta i kod većine bolesnika, njih 43 (83%), bila je odsutna eliminacija radionuklida u želudac. Procenjujući vrednosti RI pre prve BD i duže vreme posle nje, pokazano je da određene vrednosti RI ukazuju na remisiju ili relaps bolesti. Razlika vrednosti RI posle BD veća od 50% pokazala se kao pouzdan prediktor dugotrajne remisije. Starost i pol bolesnika nisu uticali na rezultat dilatacije, ali su bolesnici mlađi od 40 godina imali veći rizik od ranog neuspeha (6 bolesnika u toku prve godine posle BD). Nalaz SJ ukazao je na to da je prva BD bila inicijalno uspešna kod 50 bolesnika, a posle perioda praćenja kod 41 (79%) bolesnika. **Zaključak**. Dvofazna scintigrafija jednjaka u ležećem/stojećem položaju je najpogodnija metoda za dijagnostikovanje i praćenje ahalazije. Za procenu i predviđanje terapeutskog odgovora RI je važan pokazatelj. Razlika RI veća od 50% posle BD je pouzdani prediktor duže remisije. Starost i pol bolesnika ne utiču na rezultat dilatacije jednjaka, ali bolesnici mlađi od 40 godina imaju veći rizik od ranog neuspeha lečenja.

Ključne reči:
dilatacija balonom; jednjak; jednjak, ahalazija; prognoza; scintigrafija; lečenje, ishod.

Introduction

Achalasia is a primary esophageal motor disorder characterized by the loss of peristalsis and the failure of relaxation of the lower esophageal sphincter (LES). It is caused by the loss of myenteric neurons, probably as a consequence of a nonreversible autoimmune process [1, 2]. The aim of the treatment is primarily to relieve dysphagia. The most frequent therapeutic method is pneumatic balloon dilatation (BD) which alleviates transit through the LES and leads to a long remission in most patients [3–8]. Some patients are subjected to failed dilatation or a shorter or longer period ending with disease relapse. Clinical success can be evaluated by several methods: follow-up with patient's symptoms (symptom scores), radiography of esophagus, esophageal manometry, and esophageal scintigraphy (ES). ES is potentially the most convenient method because it is safe, simple, quantitative, and with low radiation dose [5, 9–13]. Due to a non-standardized protocol of investigation, ES is underestimated and neglected in diagnostic protocols [14, 15]. Numerous studies have tried to find predictive factors for the clinical success of BD [5, 12, 16–21]. The purpose of this paper was to present the ES results in achalasia treated by BD and to set parameters suitable for predicting the prognosis of the disease and, consequently, the treatment outcomes.

Methods

The data of patients were retrospectively evaluated. The diagnosis of achalasia was confirmed after a clinical evaluation, endoscopy, radiography, and manometry. All patients were evaluated with ES before and after BD. Patients with a previous unassessed dilatation, botulinum toxin, and surgical therapy were excluded. The patients were examined and followed up for a long period of time, from 1997 to 2016.

Modified BD was performed with Rigiflex balloon dilator (Boston Scientific USA), without sedation, up to the pain threshold of patients [4]. In 44 patients, one BD was performed, and in 8 patients, two BD were done due to the relapse of disease (in 7 patients) and dilatation failure (in one patient).

ES was performed in 52 patients (34 males and 18 females, aged 22–75 years, the median age was 44 years) before and after BD. In 31 patients, only two scintigraphies, before and after BD, were performed. In the remaining 21 patients, follow-up and repeated scintigraphies were continued, including the patients with therapeutic failure and repeated BD (follow-up period of 6 months to 17 years, median 26.5 months). BD was repeated in 8 patients, and these were followed up and evaluated over time.

Two-phase scintigraphy was performed. The first phase was in the supine position. A patient swallowed 10 mL of water with 18.5 MBq of ^{99m}Tc-pertechnetate. Imaging was performed with gamma camera Siemens Orbiter in anterior projection with the camera head over the patient (1 image every 4 sec; 16 images were made). After the first phase, the patient stood up, and after moving the head of the camera, it was positioned in front of the standing patient. A glass with 100 mL of water was added to the patient, and he/she swallowed the water with simultaneous imaging: 16 images every 4 sec, and additional 4 images every 4 sec (these images were made after positioning the patient's stomach in the center of the camera field). The recorded images were analyzed visually, and the time-activity curves were constructed. After the imaging, the retention index (RI) of esophageal radioactivity was calculated using the formula RI (%) = E/(E + V) × 100% (E – esophageal activity; V – stomach activity and bowel activity if present). Background activity correction was applied when the ratio E/V or V/E was more or equal to 3 : 1. The presence of gastric activity in supine and standing position before drinking a glass of water was recorded.

BD was successful if the RI value after BD decreased more than 50% from its value before BD. Relapse occurred if the RI value during the follow-up increased more than 50% of its basic value before dilatation or the RI value was higher than 30% of its basic value and with a constant increase on at least two consecutive control scintigrams.

The statistical analysis was done in all patients and in the group of the followed patients. The analysis in the followed patients included one patient with initially failed BD (a total of 21 patients). In the descriptive statistics, medians, frequencies, and ranges were used. Median was used as the only statistical measure of central tendency. The χ^2 test and Fisher's exact test were used to compare categorical variables presented as frequencies. The Mann-Whitney *U* test and Wilcoxon signed ranks test analyzed numeric variables presented as medians. The predictive value of the

RI value after BD was assessed with logistic regression analysis. The result was statistically significant when the *p*-value was less than 0.05. The used statistical software was StatsDirect version 2.7.

Results

In all patients, ES was performed before BD. Scintigraphic findings were typical. In the supine position, the esophagus was passively filling without evidence of motility (Figure 1), and there was no elimination of activity to the stomach after 60 seconds (43 patients) or with minimal elimination in some patients (9 patients). After the patient's transition to a standing position, there were more cases of gastric activity before drinking water (16 patients). After drinking 100 mL of water, variable esophageal retention was recorded (in 27 patients, RI was higher than 50%). In 14 patients, the maximal 100% retention occurred. In 25 patients, retention was less than 50%.

After BD in all patients, esophageal scintigrams obtained in the supine position were similar to the previous before BD (absent motility), with a higher number of patients with visible gastric elimination (21 patients). Images in standing position showed much more patients with gastric elimination before additional water load (39 patients). The great reduction of radionuclide retention was registered after drinking water in 50 patients. Maximal radionuclide retention after BD in successful cases was 26.2%.

In 50 patients, the first BD was successful, while in 2 patients, it was unsuccessful (in one of them, the second successful dilatation was performed, and the patient was followed up for 2 years). The range of RI values in all patients before BD and after BD is presented in Table 1. Age and gender showed no statistically different RI values after BD. In 21 patients, follow-up was continued, including one patient with failed BD.

By evaluating values before and a long time after the first BD (during follow-up), some RI values indicated remission or relapse of the disease. The RI value over 50% before

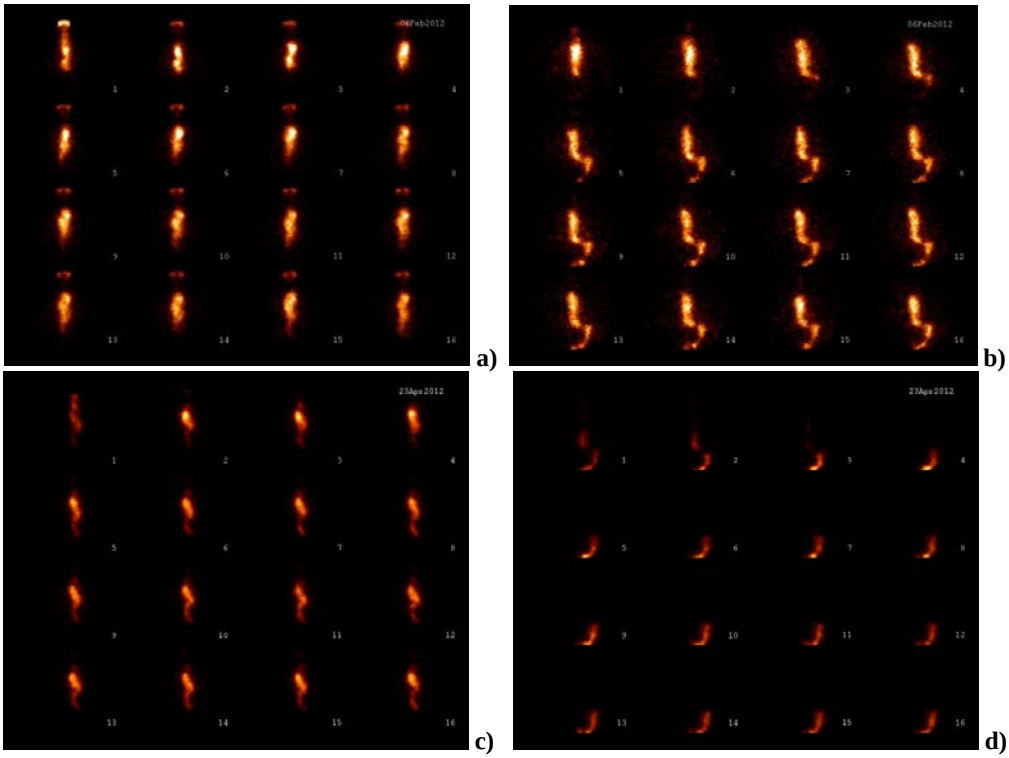

Fig. 1 – The esophageal scintigraphic images of a patient with successful balloon dilatation (BD): scintigrafic images obtained in supine and upright position before BD (a, b) and after BD (c, d).

Table 1

Scintigraphic results in patients with achalasia

Parameter	Before BD	After BD	*p*
Retention index (%)			
all patients (n = 52), median (range)	59.6 (6.5–100)	2.95 (0.2–54.1)	< 0.01[a]
aged > 40 years (n = 29), median	70	2.7	< 0.01[a]
aged <40 years (n = 23), median	58.7	3.2	ns[b]
male (n = 34), median	60.7	2.8	< 0.01[a]
female (n = 18), median	53.85	3.1	ns[b]
Gastric activity (+/-), n	9 / 43	21 / 31	< 0.05[c]
Gastric standing activity (+/-), n	16 / 36	39 / 13	< 0.01[c]

BD – balloon dilatation; [a] – Wilcoxon test; [b] – Mann-Whitney test; [c] – Chi-squared test; ns – non-significant.

BD and the difference of the RI values before and after BD higher than 50% were significantly different in patients with and without successful BD (Table 2). In our study, the RI values lower than 3% were more often in successful BD (7 successful and 3 unsuccessful BD), but the difference was not significant. The age and gender of patients had no statistical significance.

The predictive value of RI before and after BD and the impact of different factors were tested with logistic regression analysis. Variables including the RI values, age, and gender were analyzed in relationship to a therapeutic response (success or failure). The analysis confirmed the high predictive value of 50% RI difference after BD (Table 2) and its power to predict longer remission. An increased number of early dilatation failures in patients younger than 40 years was observed. Initially, failed BD occurred only in 2 patients younger than 40 years. During a one-year follow-up, all four additionally failed BD were registered in patients younger than 40 years. All three patients older than 40 years failed later – 2.5 years, 5 years, and 6 years after BD. These data suggested the impact of age on dilatation outcome, but the statistical significance of age was not confirmed (Table 2). The gastric radioactivity early after BD (the first control ES) was more often registered in the supine position (21/9, $p < 0.05$) (Table 2). The presence of eliminated stomach radioactivity that occurred in a standing position before water drinking was indicative of successful BD (39/16, $p < 0.01$). Analysis of gastric activity in patients on follow-up showed more cases of gastric activity after BD (15/6) but without a statistical difference in patients with successful and unsuccessful dilatation.

In 11 of the followed patients, remission that lasted from 2 months to 3.5 years was registered. In 9 patients during the follow-up period, relapse of the disease occurred (after 6 months to 6 years), and 7 of them were subjected to the second dilatation that was followed up during the next 1 month to 11 years. Of the initial 52 patients, 41 patients were with the first successful BD (Table 3), thus the percentage of success was 79%. The total number of unsuccessful BD one

Table 2

Scintigraphic results in followed patients with achalasia

Parameter	Balloon dilatation (BD), n		*p**
	successful (n = 11)	unsuccessful (n = 10)	
RID (%)			
> 50	8	2	< 0.05
< 50	3	8	
Age (years)			
> 40	3	3	ns
< 40	8	7	
> 40 (first year)	6	0	ns
< 40 (first year)	9	6	
Gender			
male	8	7	ns
female	3	3	
RI after BD			
> 3%	4	7	ns
< 3%	7	3	
GSA after BD			
+	9	6	ns
–	2	4	
	Logistic regression analysis (odds ratio)		*p*
RID 50%	10.67		0.023
RI 3%	3.571		ns
Age	0.875		ns
Gender	1.142		ns

***Fischer's exact test; RID – retention index difference; RI – retention index; GSA – gastric standing activity; ns – non-significant.**

Table 3

Number of successful and unsuccessful first balloon dilatation (SBD and NSBD, respectively) in all patients and in followed patients

Patients	SBD	NSBD	SBD follow-up	NSBD follow-up
Total number (n = 52)	41	11	11	10
male (n = 34)	26	8	8	7
female (n = 18)	15	3	3	3
Age (years)				
> 40 (n = 29)	25	4	3	3
< 40 (n = 23)	16	7	8	7

year after BD was 6, while including the maximal follow-up was 10. After the second BD, a new relapse occurred in two patients (after 1 month and after 1.5 years).

The images of a patient with successful BD are presented in Figure 1. The RI value before dilatation was 70%, and after dilatation was only 0.7%. After BD, spontaneous gastric activity in an upright position was registered.

Discussion

Symptom scores have been used for a long time for therapy assessment, but some authors declined their significance and predictive value [5, 8, 12]. A timed barium esophagogram has been recommended recently [22, 23], but it is a preferentially morphologic method with low functional and physiologic data. Manometry is the basic method of diagnosis, but some authors recommend using it for follow-up with patients [20, 21].

Scintigraphic imaging in the supine position is considered important for diagnosing achalasia (evaluation of motility), but imaging in a standing position with a load of additional water is considered necessary for reliable disease follow-up. Two-phase esophageal supine/standing scintigraphy with additional water load is an absolutely convenient and recommended method for noninvasive diagnostic and therapeutic management of achalasia. If standing position is not possible, a patient can be imaged in a sitting position.

The predictor of successful BD is the achieved great RI reduction (50%) after BD (the greater the difference, the bigger the effect of BD). The effect of the low value of RI was expected to contribute to longer remission but was not statistically confirmed, probably because of the small number of followed patients.

In the total group of patients, the change in gastric appearance after BD was statistically significant, but in the smaller group, with longer follow-up, statistical difference was not found. Gastric activity in supine and standing position were signs of successful therapy effect in first months after BD but without predictive value for a long remission.

The results of Jeon et al. [5] are based on two initial scintigraphies and the follow-up by symptom scores. Results would be more complete if control scintigraphies could be performed. What is unusual in the results of this study is that all 13 failed BD were registered within 6 months after BD. Our results showed that 2 patients failed initially, 4 patients after 6 to 8 months, and the remaining 4 patients after 2.5 to 6 years. The analysis of the esophageal time-activity curve and its use to count functional parameters was the main issue of many studies [5, 9–11]. The problem with that approach is that registered counts and counted parameters highly depend on the variable position of the liquid bolus in the esophagus. Our solution to image and count esophageal and gastric radioactivity was not proposed in published papers. We consider that our method is more reliable for evaluating achalasia. Jeon et al. [5] used a higher diagnostic dose without additional flushing water so a greater unswallowed activity could remain in the mouth.

The failure of BD occurred more often in patients under 40 years of age, but the impact of age was not statistically confirmed, contrary to other studies [3, 17]. All failed BD initially and during one year of follow-up occurred only in patients younger than 40 years (6 patients), but most of these followed younger patients (9 of them) had successful dilatation outcome, and this result caused the negative statistical significance of age.

The patient's gender was not associated with the failure of dilatation and the same appears in most studies [4, 5, 8].

The limitations of the study were the following: this was a retrospective analysis, there were great differences in the period of follow-up, the number of followed patients was low, the RI ratio depended on both esophageal and stomach condition, and the scintigraphic results were analyzed by only one observer.

Inspired by the introduction of high-resolution esophageal manometry (HRM) [24] which defined more subtypes of achalasia we highly suggest combining these two methods for diagnosis and follow-up of achalasia. HRM reveals new data about the normal esophageal function and motility disturbance in achalasia [25, 26]. Therefore, we recommend using scintigraphy as a complementary method in every patient subjected to HRM.

Besides BD, other therapeutic possibilities are being developed [27–32], but this method will remain the most convenient option for most patients.

Conclusion

Esophageal two-phase supine/standing scintigraphy is most suitable for diagnosing and follow-up of achalasia. The RI represents an important parameter for the evaluation and prediction of therapeutic response. The RI difference higher than 50% after balloon dilatation is a reliable predictor of a longer remission. Age and gender have no impact on dilatation outcome, but patients younger than 40 years have a higher risk of early therapeutic failure.

REFERENCES

1. *Kahrilas PJ, Boeckxstaens G.* The spectrum of achalasia: lessons from studies of pathophysiology and high-resolution manometry. Gastroenterology 2013; 145(5): 954–65.
2. *Furuzawa-Carballeda J, Torres-Landa S, Valdovinos MÁ, Coss-Adame E, Martín Del Campo LA, Torres-Villalobos G.* New insights into the pathophysiology of achalasia and implications for future treatment. World J Gastroenterol 2016; 22(35): 7892–907.
3. *Eckardt VF, Gockel I, Bernhard G.* Pneumatic dilation for achalasia: late results of a prospective follow up investigation. Gut 2004; 53(5): 629–33.
4. *Doder R, Perišić N, Tomašević R, Mirković D, Janković Z, Djordjević Z.* Long term outcome of a modified balloon dilatation in the treatment of patients with achalasia. Vojnosanit Pregl 2013; 70(10): 915–22.

5. *Jeon HH, Youn YH, Rhee K, Kim JH, Park H, Conklin JL.* For patients with primary achalasia the clinical success of pneumatic balloon dilatation can be predicted from the residual fraction of radionuclide during esophageal transit scintigraphy. Dig Dis Sci 2014; 59(2): 375–82.
6. *Cheng P, Shi H, Zhang Y, Zhou H, Dong J, Cai Y,* et al. Clinical effect of endoscopic pneumatic dilation for achalasia. Medicine 2015; 94(28): e1193.
7. *Moonen A, Annese V, Belmans A, Bredenord AJ, Bruley des Varannes S, Costantini M*, et al. Long-term results of the european achalasia trial: a multicentre randomised controlled trial comparing pneumatic dilation versus laparoscopic Heller myotomy. Gut 2016; 65(5): 732–9.
8. *Gupta SJ, Gaikwad NR, Samarth AR, Gattewar SR.* Pneumatic balloon dilatation for achalasia cardia: outcome, complications, success, and long-term follow-up. Euroasian J Hepatogastroenterol 2017; 7(2): 138–41.
9. *Robertson CS, Hardy JG, Atkinson M.* Quantitative assessment of the response to therapy in achalasia of the cardia. Gut 1989; 30(6): 768–73.
10. *Parker DR, Swift GL, Adams H, Smith PM, Richards AR.* Radionuclide esophageal transit studies in achalasia before and after balloon dilatation. Dis Esophagus 1996; 9(1): 42–5.
11. *Chawda SJ, Watura R, Adams H, Smith PM.* A comparison of barium swallow and erect esophageal transit scintigraphy following balloon dilatation for achalasia. Dis Esophagus 1998; 11(3): 181–7; discussion 187–8.
12. *Ehsani Ardakani MJ.* Esophageal Transit Scintigraphy, Manometry, and Barium Swallow in Assessment of Response to Balloon Dilatation in Achalasia, Iran J Radiol 2006; 4(1): e79230.
13. *Chung JJ, Park HJ, Yu JS, Hong YJ, Kim JH, Kim MJ, Lee SI.* A comparison of esophagography and esophageal transit scintigraphy in the evaluation of usefulness of endoscopic pneumatic dilatation in achalasia. Acta Radiol 2008; 49(5): 498–505.
14. *Stefanidis D, Richardson W, Farrell TM, Kohn GP, Augenstein V, Fanelli RD.* Society of American Gastrointestinal and Endoscopic Surgeons. SAGES guidelines for the surgical treatment of esophageal achalasia. Surg Endosc 2012; 26(2): 296–311.
15. *Vaezi MF, Pandolfino JE, Vela MF.* ACG clinical guideline: diagnosis and management of achalasia. Am J Gastroenterol. 2013; 108(8):1238-49; quiz 1250.
16. *Farhoomand K, Connor JT, Richter JE, Achkar E, Vaezi MF.* Predictors of outcome of pneumatic dilation in achalasia. Clin Gastroenterol Hepatol 2004; 2(5): 389–94.
17. *Mehta R, John A, Sadasivan S, Mustafa CP, Nandkumar R, Raj V,* et al. Factors determining successful outcome following pneumatic balloon dilatation in achalasia cardia. Indian J Gastroenterol 2005; 24(6): 243–5.
18. *Dagli U, Kuran S, Savas N, Ozin Y, Alkim C, Atalay F,* et al. Factors predicting outcome of balloon dilatation in achalasia. Dig Dis Sci 2009; 54(6): 1237–42.
19. *Tanaka Y, Iwakiri K, Kawami N, Sano H, Umezava M, Kotoyori M,* et al. Predictors of a better outcome of pneumatic dilatation in patients with primary achalasia. J Gastroenterol 2010; 45(2): 153–8.
20. *Alderliesten J, Conchillo JM, Leeuwenburgh I, Steyerberg EW, Kuipers EJ.* Predictors for outcome of failure of balloon dilatation in patients with achalasia. Gut 2011; 60(1): 10–6.
21. *Yamashita H, Ashida K, Fukuchi T, Nagatani Y, Koga H, Senda K,* et al. Predictive factors associated with the success of pneumatic dilatation in Japanese patients with primary achalasia: a study using high-resolution manometry. Digestion 2013; 87(1): 23–8.
22. *Neyaz Z, Gupta M, Ghoshal UC.* How to perform and interpret timed barium esophagogram. J Neurogastroenterol Motil 2013; 19(2): 251–6.
23. *Park YM, Jeon HH, Park JJ, Kim JH, Youn YH, Park H.* Correlation between timed barium esophagogram and esophageal transit scintigraphy results in achalasia. Dig Dis Sci 2015; 60(8): 2390–7.
24. *Pandolfino JE, Kwiatek MA, Nealis T, Bulsiewitz W, Post J, Kahrilas P. Achalasia*: A new clinically relevant classification by high-resolution manometry. Gastroenterology 2008; 135(5): 1526–33.
25. *Roman S, Gyawali CP, Xiao Y, Pandolfino JE, Kahrilas PJ.* The Chicago classification of motility disorders: an update. Gastrointest Endosc Clin N Am 2014; 24(4): 545–61.
26. *Rohof WOA, Bredenoord AJ.* Chicago classification of esophageal motility disorders: lessons learned. Curr Gastroenterol Rep 2017; 19(8): 37.
27. *Müller M, Eckardt AJ, Wehrmann T.* Endoscopic approach to achalasia. World J Gastrointest Endosc 2013; 5(8): 379–90.
28. *Uppal DS, Wang AJ.* Update on the endoscopic treatments for achalasia. World J Gastroenterol 2016; 22(39): 8670–83.
29. *Youn YH, Minami H, Chiu PW, Park H.* Peroral endoscopic myotomy for treating achalasia and esophageal motility disorders. Neurogastroenterol Motil 2016; 22(1): 14–24.
30. *Tuason J, Inoue H.* Current status of achalasia management: a review on diagnosis and treatment. J Gastroenterol 2017; 52(4): 401–6.
31. *Arora Z, Thota PN, Sanaka MR.* Achalasia: current therapeutic options. Ther Adv Chronic Dis 2017; 8(6–7): 101–8.
32. *Baniya R, Upadhaya S, Khan J, Subedi SK, Shaik Mohammed T, Ganatra BK,* et al. Laparoscopic esophageal myotomy versus pneumatic dilation in the treatment of idiopathic achalasia: a meta-analysis of randomized controlled trials. Clin Exp Gastroenterol 2017; 10: 241–8.

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