ISSN: 2836-4961

Case Report

General Surgery and Clinical Medicine

Renal Nutcracker Syndrome: a Case Series and Systematic Review of an Uncommon and Underdiagnosed Condition

Sajjaad H. Samat[1*], Sean K. Park[1], Eric J. Weiler[1], Mohammad Torabi[1], Kyle Schank[1] and J Lin[1]

[1]*Department of Surgery, Michigan State University, East Lansing, MI, USA*

[*]Corresponding Author
Sajjaad H. Samat, Department of Surgery, Michigan State University, East Lansing, MI, USA

Submitted: 2024, Apr 20; **Accepted:** 2024, May 10; **Published:** 2024, May 16

Citation: Samat, S. H., Park, S. K., Weiler, E. J., Torabi, M., Schank, K., et al. (2024). Renal Nutcracker Syndrome: a Case Series and Systematic Review of an Uncommon and Underdiagnosed Condition. *Gen Surgery Clin Med, 2*(2), 01-13.

Abstract

Introduction: *Renal nutcracker syndrome (NCS) is a rare cause of chronic pain, hematuria, and urogenital issues. Most often NCS presents due to compression of the left renal vein (LRV) between the aorta and the superior mesenteric artery (SMA). The demographics and clinicopathologic features are not well recognized in the medical community broadly, leading to misdiagnosis and treatment that is ineffective. We present a systematic review of NCS case reports and case series, with the goal of establishing common features in presentation that will allow this condition to be more recognizable.*

Method: *A literature search was conducted through PubMed, SCOPUS, and Cochrane databases for the past 10 years (November 2012 to November 2022) for confirmed cases of NCS. Additionally, seven of our own clinical cases are included as a case series and included in the review. Data such as age, sex, symptoms, and treatment were extrapolated and aggregated.*

Results: *Forty studies and our own series were included in the review, for a total of 73 individual patient cases. The mean age at diagnosis was 36. The vast majority of patients were female (79.5%). Left flank pain was the most common presenting symptom (61.6%) with hematuria presenting as the second most common (52.1%). However, a significant proportion of patients presented with pelvic pain (37.0%), abdominal pain (15.1%), as well as nausea, vomiting, and weight loss (12.3%). Many patients also had urogenital symptoms (24.7%), such as dyspareunia, dysmenorrhea, testicular pain, UTI, urinary frequency, or uterine bleeding. Diagnosis was almost always made with computed tomography. Ultrasound generally served to augment the diagnosis. Treatment modalities were highly varied, although endovascular stenting was most commonly done (38.4%). Other options included left renal vein transposition, left renal vein bypass, PTFE cuff placement, renal auto transplantation, nephrectomy, and conservative management with pain control and nutritional support. 1 Posted on 7 Dec 2022 | The copyright holder is the au-thor/funder.*

Conclusion: *NCS is an uncommon cause of hematuria, flank pain, abdominal symptoms, and urogenital symptoms that most commonly affects young females. It presents with a variety of symptoms but should be in the differential for otherwise healthy patients presenting with hematuria, left flank pain, or urogenital symptoms. CT angiography and Doppler ultrasound are useful adjuncts in making this diagnosis. Treatment modalities range from minimally invasive to open surgery. The consequence of a missed diagnosis can lead to years of chronic pain and prescription opioid use. Thus, it is essential that awareness of this condition increases.*

Keywords: Vascular Surgery, Abdominal Pain, Hematuria, Renal Vein, Renal Nutcracker Syndrome

1. Introduction

A constellation of symptoms secondary to left renal vein (LRV) compression was first described in the 1950s and coined "Nutcracker syndrome" in 1972. Renal nutcracker syndrome (NCS) is a rare cause of chronic pain, hematuria, and urogenital issues. Compression of the LRV is most often anterior, between the superior mesenteric artery (SMA) and abdominal aorta. NCS also occurs from posterior compression of the LRV between the aorta and vertebral column. [3] Patients typically present with chronic left flank, pelvic, or abdominal pain. Other symptoms include hematuria, nausea, vomiting, weight loss, and pelvic congestion syndrome. Failure to diagnose NCS in the presence of these non-specific symptoms often leads to referrals to years of ineffective pain treatment, including referral to pain specialists, opioids, and nerve

stimulators.

This review examined case reports and case series of NCS over the past 10 years to highlight which symptoms are most common, the diagnostic workup, and proper management of NCS.
Overall, we include 40 case reports and series in addition to our own series. [4-43]

2. Methods

A literature search was conducted through PubMed, SCOPUS, and Cochrane Databases from October 2012 to October 2022 for all confirmed cases of Nutcracker Syndrome. Additionally, seven cases from our own institution were included. Informed consent was not obtained as there are no identifiable patient factors in any of the records reviewed.

2.1 Consent: Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

2.2 Sélection Criteria: The PRISMA diagram (figure 1) describes the selection process. All case reports and case series involving patients with confirmed diagnosis of NCS were included for screening. Systematic reviews, meta-analyses, and other types of papers were excluded with one exception. A systematic review that contained an individual case report was included, but only data from the case report was used in our review. [35] Reports of pediatric patients (under age 18) were excluded, as were reports in languages other than English and those where NCS was not ultimately diagnosed. Reports with incomplete patient data were also excluded. Most articles were excluded by screening abstracts but several full text articles were also excluded for the above reasons after review. Seven cases from our own institution were included. Ultimately, 40 articles were included.

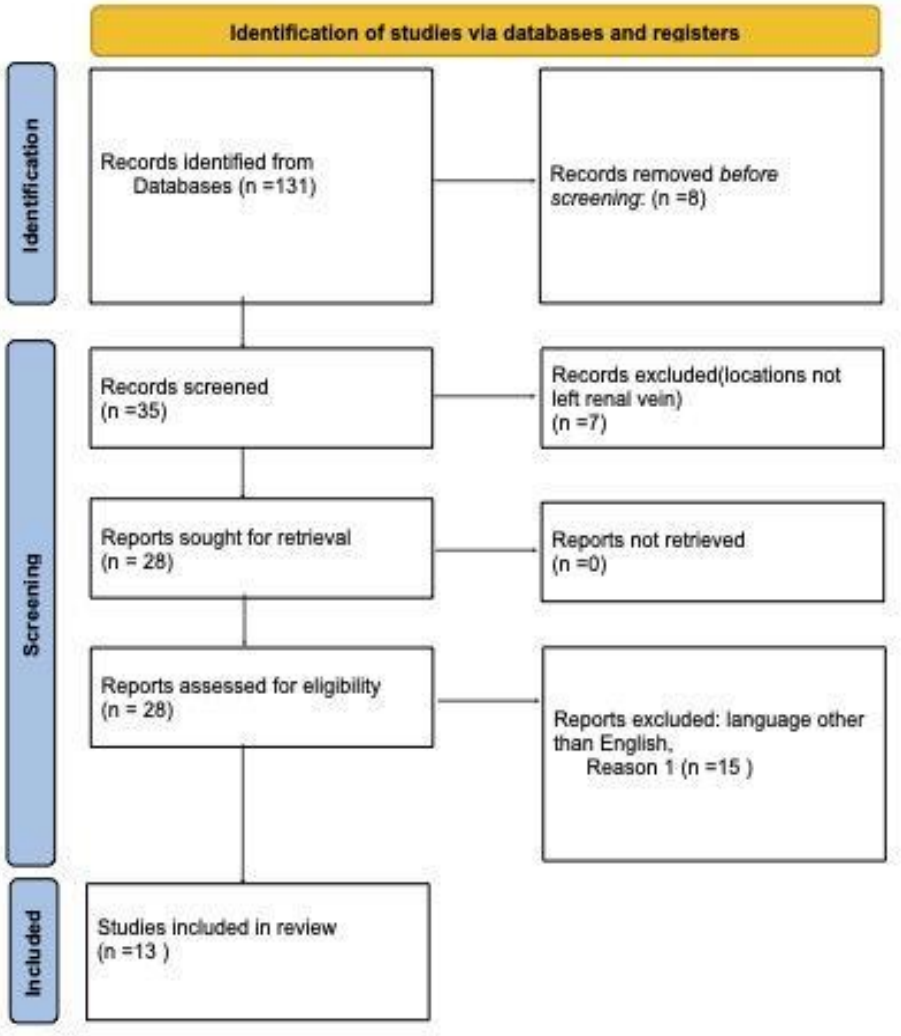

Figure 1: Prisma Flow Diagram Showing Search Algorithm Used for Systematic Review.

2.3 Data Extraction: The following data was retrieved and appears in table 1: lead author, year of publication, country of origin, age, sex, presenting symptoms, diagnostic tests, location of the compression, presence of pelvic venous dilation, and type of treatment or procedure.

2.4 Statistical Analysis: Descriptive statistics were used to present the demographic, clinical, pathologic and treatment features of the pooled data from all the selected studies. This appears in the body of the paper below and in table 2.

Authors	Year	Age	Sex	Symptoms/Comorbidities	Hematuria	Workup/Imaging	Location (Anterior/Posterior)	Treatment
Copetti et al.	2017	31	F	Left flank pain	Yes	Renal Duplex	Anterior	No treatment reported
Miler	2017	26	F	Left flank pain, MTS	Yes	Renal duplex, CTA, IVUS	Anterior	Open gonadal vein transposition to left CIV
Taneja et al	2018	34	F	Left flank pain	No	Renal Duplex, CT Abdomen and Pelvis, IVUS.	Anterior	Endovascular Stent
Yu	2019	46	F	Left flank pain	Yes	CT Abdomen and pelvis	Anterior	Left renal vein transposition
Yu	2019	19	M	Left flank pain, Varicosities	Yes	CT Abdomen and pelvis	Anterior	Left renal vein transposition
Yu	2019	36	M	No flank pain, Ane-	Yes	CT Abdomen and pelvis	Anterior	Left renal vein transposition

				mia				
Avgerinos	2019	21	F	Left flank pain	No	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	50	F	Left flank pain	No	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	25	F	Left flank pain, N/V	No	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	33	F	Left flank pain, Varicosities	No	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	50	F	Chronic pelvic pain	No	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	51	F	Left flank pain	No	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	30	F	chronic pelvic pain	No	CT Venography, IVUS.	NR	Endovascular Stent

Avgerinos	2019	39	F	Left flank pain, Varicosities	No	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	23	M	Left flank pain, Varicosities	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	24	F	Left flank pain	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	21	F	Left flank pain, Proteinuria	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	36	F	Chronic pelvic pain, Varicosities	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	55	F	Left flank pain	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgerinos	2019	26	F	Left flank pain,	Yes	CT Venography, IVUS.	NR	Endovascular Stent

				Pro-teinuria				
Avgeri-nos	2019	69	F	Left flank pain	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgeri-nos	2019	19	F	Left flank pain, recur-rent UTI	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgeri-nos	2019	38	F	Left flank pain	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Avgeri-nos	2019	76	F	Left flank pain, Vari-cosities	Yes	CT Venography, IVUS.	NR	Endovascular Stent
Dahman	2019	10	F	Gross Hemat uria	Yes	Renal Duplex and CTA	Anterior	Conservative
Dunphy	2019	39	F	Gen-eral ab-domina l pain	Yes	CT Abdomen and pelvis	Anterior	Conservative
Kim	2019	18	M	NR	No	Renal Duplex and CT	Anterior	NR

Kim	2019	72	F	NR	No	Renal Duplex and CT	Anterior	NR
Kim	2019	49	F	NR	No	Renal Duplex and CT	Posterior	NR
Patel et al.	2019	38	F	Left flank pain, Gastro-tro-paresis	No	MRI Abdomen	Anterior	Open Renal Autotransplantation
Belczak	2020	42	F	Left flank pain	Yes	CT Venography, IVUS.	Anterior	Endovascular Stent

Table 1: Reported Cases of Nutcracker Syndrome
N/V: nausea/vomiting
NR: Not Reported
CIV: Common iliac vein
MTS: May Thurner Syndrome

Sex	**n**			**Imaging Modality**	**n**	
Female	58	79.5%		CT	29	39.7%
Male	15	20.5%		CTA	12	16.4%
Age				CTV	29	39.7%
Age range	18 to 77			CT in any form (CT, CTA, CTV)	68	93.2%
Median age	34			MRI/MRA	4	5.5%

Mean age	36		US	24	32.9%
n patients below age 40	54	74.0%	**Treatment Modality**	**n**	
Radiographic Findings	**n**		Medical management*	9	12.3%
Anterior LRV compression	41	56.2%	No treatment**	5	6.8%
Posterior LRV compression	3	4.1%	Endovascular stent	28	38.4%
Anterior and posterior LRV compression	1	1.4%	Robot-assisted Extravascular LRV stent	6	8.2%
Location of LRV compression not stated	27	37.0%	LRV transposition	11	15.1%
LRV Compression by dilated splenic vein	1	1.4%	Open LRV bypass (PTFE or vein graft)	2	2.7%
Pelvic venous dilatation	32	43.8%	Robotic laparoscopic LRV PTFE cuff	3	4.1%
Presenting Symptoms	**n**		Renal autotransplant or nephrectomy	2	2.7%
Hematuria	38	52.1%	Transposition of vein other than LRV	2	2.7%

Left flank pain	45	61.6%		Ligation/embolization other than LRV***	6	8.2%
Pelvic pain	27	37.0%		*Medical management includes pain control, anti-hypertensives, and nutritional support for weight gain. **This includes patients who were not treated for NCS but were treated for concomitant conditions like SMAS. ***2 of the 6 cases also were treated with endovascular stenting		
Abdominal pain	11	15.1%				
Nausea, vomiting, weight loss	9	12.3%				
Urogenital Symptoms	18	24.7%				
Concomitant conditions	**n**					
May-Thurner Syndrome (MTS)	8	11.0%				
Superior Mesenteric Artery Syndrome (SMAS)	10	13.7%				

Table 2: Statistical Analysis

3. Results

RESULTS: Forty studies and our own series were included in the review, for a total of 73 individual patient cases. The mean age at diagnosis was 36. The vast majority of patients were female (79.5%). Left flank pain was the most common presenting symptom (61.6%) with hematuria presenting as the second most common (52.1%). However, a significant proportion of patients presented with pelvic pain (37.0%), abdominal pain (15.1%), as well as nausea, vomiting, and weight loss (12.3%). Many patients also had urogenital symptoms (24.7%), such as dyspareunia, dysmenorrhea, testicular pain, UTI, urinary frequency, or uterine bleeding. Diagnosis was almost always made with computed tomography. Ultrasound generally served to augment the diagnosis. Treatment modalities were highly varied, although endovascular stenting was most commonly done (38.4%). Other options included left renal vein transposition, left renal vein bypass, PTFE cuff placement, renal auto transplantation, nephrectomy, and conservative management with pain control and nutritional support.

The seven patients treated at our institution appear in Table 1 as "present cases." All seven complained of long-term severe left flank and abdominal pain. Other symptomatology included hematuria of unknown etiology and pelvic congestion symptoms. These patients had been treated for non-specific pain. Many were on long

term opioid therapy.

There were six females and one male. Age ranged from 19 to 58. Our initial workup consisted of CT venography, which showed LRV enlargement in all seven patients. IVUS was subsequently used in all seven patients and showed LRV diameter and degree of compression supportive of NCS.

One patient underwent endovascular intervention with stenting. One had gonadal vein transposition. Three underwent robot-assisted laparoscopic LRV PTFE cuff placement. One had LRV bypass with PTFE. One had LRV transposition (Figure 2). All patients reported reduced postoperative pain. Some had lingering mild discomfort but opioid pain medications were discontinued in all seven patients. They reported significant improvements in quality of life and symptoms at follow up visits.

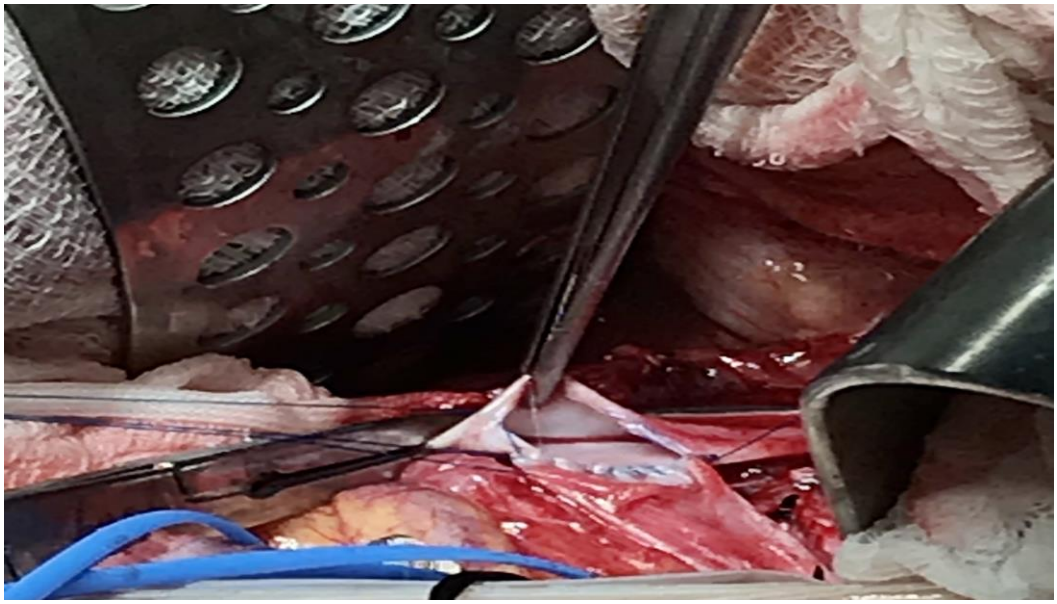

Figure 2: Renal Vein Transposition

3.1 Systematic Review

Forty articles met our selection criteria, as described in Figure 1. Of these, four were case series. [9, 37, 38, 43] The remaining 36 articles were individual case reports. [4-8, 10-36, 39-42]. From these forty articles, 66 individual cases were reported. Our seven clinical cases were included for a total of 73 cases (Table 1).

The majority of the patients were young females complaining of left flank pain and/or hematuria. Age at diagnosis ranged from 18 to 77. Mean age was 36 and median was 34. Eight-two percent of patients were below age 50. The majority of patients (79.5%) were female. The most common presenting symptom was left flank pain (61.6%), followed by hematuria (52.1%), which included both gross and microscopic hematuria. About a third of patients (37.0%) complained of pelvic pain. Notably, 24.7 percent experienced urogenital symptoms such as pelvic congestion syndrome, dyspareunia, dysmenorrhea, urinary frequency, dysuria, or testicular and scrotal pain. A handful of patients (12.3%) had concomitant superior mesenteric artery syndrome (SMAS) and 11.0 percent had concomitant May-Turner syndrome (MTS).

LRV location was mostly anterior. Only three patients had posterior NCS--one of our clinical cases and two case reports. [14, 17]. Location was not described in 37 percent of cases. Forty-one patients had anterior compression, which is 56.2 percent of the total and 89.1 percent of cases that reported location. One case described a patient with an anterior and posterior LRV, both of which were compressed. [13] Another report described compression of the LRV by a dilated splenic vein, in a patient with splenomegaly. [29] Imaging revealed enlarged gonadal veins, adnexal varices, or varicocele in 42.5 percent of cases.

Some form of computed tomography (CT) was used in the vast majority of cases (93.2%). This includes CT abdomen pelvis, CT angiogram (CTA), and CT venogram (CTV). Of the five cases that did not use CT, four used MRI. One case used Doppler ultrasound alone to diagnose NCS. In 21 cases (28.8%), ultrasound was used in combination with one of the forms of CT. Angiography, venography, and intravascular ultrasound (IVUS) were also used but generally as part of an intervention rather than primary diagnosis. Exploratory laparotomy or diagnostic laparoscopy was also seen in three cases when a diagnosis other than NCS was suspected.

Treatment modality was variable, although endovascular stenting was most common, appearing in 38.4% of cases. Other endovascular therapies included embolization of a left ovarian vein and a left second lumbar vein respectively in two cases. Two of the LRV stent cases also included embolization of the left ovarian vein. Med-

ical management, including anti-hypertensives, pain medication, and nutritional support were found in only 12.3 percent of cases. There were a wide variety of non-endovascular procedures done. The most common was LRV transposition, done in 15.1 percent. Four of these were noted to have been done with a retroperitoneal approach. There were six cases (8.2%) in which robot-assisted laparoscopic extravascular LRV stenting was performed. Other surgical options included robot-assisted laparoscopic LRV PTFE cuff placement (3 cases), LRV bypass with femoral vein graft (1 case) or PTFE (1 case), gonadal vein transposition (2 cases), varicocele ligation, gonadal vein ligation, renal auto transplant, splenectomy, and nephrectomy. Five cases did not provide information on treatment, symptoms resolved spontaneously, or treatment of another condition (i.e. SMAS) resulted in relief of symptoms.

4. Discussion

NCS is an uncommon condition that presents in varied ways. However, this review demonstrates that commonalities exist among NCS patients, which should raise suspicion among clinicians. The majority of patients were young, female, and present with left flank pain and/or hematuria, which is likely due to the rupture of thin-walled varices formed from renal hypertension into the collection system. [3] Features of pelvic congestion, such as dyspareunia, dysmenorrhea, scrotal or testicular pain, or urinary issues, might also evince NCS. Even refractory headaches can be related to LRV compression. Any of these symptoms in this patient population should raise suspicion of NCS in the absence of a more obvious diagnosis. Additionally, a normal to low BMI also appears to be associated with NCS. Not enough reports in this review included BMI information for us to include this data, but anecdotally, most reports of NCS occur in normal or underweight patients. A decreased aortomesenteric angle--or the angle between the SMA and aorta, risks compression of the LRV as it does to the duodenum in SMAS. [19, 45] This is more likely to be found in underweight patients, who have decreased retroperitoneal and mesenteric fat.

There are multiple imaging modalities that can be used to diagnose NCS. While the gold standard is retrograde venography, this invasive procedure is not always necessary. It is established that a pressure gradient between the LRV and inferior vena cava less than 1 mm Hg is normal, whereas greater than 3 mm Hg evinces nutcracker phenomenon and NCS with symptoms. [19, 46]. It has been suggested that this pressure gradient can be estimated fairly accurately from Doppler ultrasound, by measuring differences in flow velocities. [46] Additionally, the size of the LRV can similarly be measured with Doppler ultrasound, to demonstrate a stenosis. [15, 39, 46]. CT imaging can also show a decreased aortomesenteric angle, which when less than 38 to 45 degrees is considered abnormal. [45, 46] CT imaging can also show LRV compression. CT venography is preferable but not necessary in many of the studies we reviewed, which used CT of the abdomen pelvis or CT angiography to arrive at an NCS diagnosis. Overall, when NCS is suspected, invasive procedures are not necessary to arrive at a diagnosis. Relatively low risk procedures such as Doppler ultrasound and CT are available and should be used.

Regarding treatment, endovascular stenting was predominant. Some therapies aim at alleviating specific symptoms without disturbing the renal vein, such as gonadal vein transposition for pelvic congestion syndrome or lumbar vein embolization for headaches. Unfortunately, there was also not enough information in the reports regarding post-treatment course to determine if any of the treatment modalities are effective in the long term, and which would be preferable. More research is needed to determine the best methods of treatment. Future studies might directly compare the long-term effectiveness of conservative modalities, such as nutritional support, with endovascular or surgical options. There is still significant variation in treatment modalities. It may be that these should be adjusted to individual cases.

Our study was deficient in several ways. As stated, we did not include statistics on BMI. We also were unable to include information on outcomes of therapy, as most records did not state this. This study is retrospective in nature. Overall this was a small study population. It also included numerous institutions in different countries, which likely have different standards of practice. We did not include pediatric patients in this review.

5. Conclusion

Diagnosis of NCS remains challenging. Most patients remain symptomatic without adequate workup and are treated for non-specific chronic pain. NCS should be in the differential for patients who are below 40, female, and present with the constellation of symptoms outlined above. Diagnosis can be made with ultrasound or CT alone, without the need for angiography. Prompt referral to a vascular specialist is desirable s there are many treatment options for these patients. Increasing awareness is paramount as NCS is often overlooked and misdiagnosed. Treatment modalities range from minimally invasive to open surgery. A multi-institution or collaborative registry would be better to delineate strategies for diagnosis and management of NCS.

Funding: I Have No Funding Source. There Is No Funding To Be Reported.

References

1. El-Sadr, A. R., & Mina, E. J. T. U. (1950). Anatomical and surgical aspects in the operative management of varicocele. *The Urologic and Cutaneous Review, 54*(5), 257-262.
2. SCHEPPER, D. (1972). 'Nutcracker'phenomenon of the renal vein and venous pathology of the left kid-ney. J. *Belge Radiol., 55,* 507-511.
3. Kurklinsky, A. K., & Rooke, T. W. (2010, June). Nutcracker phenomenon and nutcracker syndrome. In *Mayo Clinic Proceedings* (Vol. 85, No. 6, pp. 552-559). Elsevier.
4. Agle, C. G., Amorim Filho, D. S., Almeida, L. C. D., & Neves, C. A. P. (2019). Endovascular treatment of Nutcracker syndrome: case report. *Jornal Vascular Brasileiro, 18*, e20180135.
5. Al-Zoubi, N. A. (2019). Nutcracker syndrome accompanying with superior mesenteric artery syndrome: a case report. *Clini-*

cal Medicine Insights: Case Reports, 12, 1179547619855383.
6. Altshuler, P. C., Garland, B. T., Jorgensen, M. E., & Gerig, N. E. (2018). Treatment-refractory vulvodynia from nutcracker syndrome: A case report. *Case Reports in Women's Health, 19,* e00071.
7. Amato, A. C. M., da Silva, A. E. C., Bernal, I. M., de Oliveira, J. C., Ribeiro, M. D. P. A., Schinzari, P. S., & Dos Santos, R. V. (2020, January). Combined nutcracker and Ehlers-Danlos syndromes: a case report. In *EJVES Vascular Forum* (Vol. 47, pp. 12-17). Elsevier.
8. Aslan, A., Barutca, H., Kocaaslan, C., Orman, S., & Şahin, S. (2016). Pulsatile mass sensation with in-tense abdominal pain; atypical presentation of the nutcracker syndrome. *Polish Journal of Radiology, 81,* 507.
9. Avgerinos, E. D., Saadeddin, Z., Humar, R., Salem, K., Singh, M., Hager, E., ... & Chaer, R. A. (2019). Outcomes of left renal vein stenting in patients with nutcracker syndrome. *Journal of Vascular Surgery: Venous and Lymphatic Disorders, 7*(6), 853-859.
10. Azhar, A. B., Zeb, N. T., Shah, S., & Khalid, A. (2019). Nutcracker syndrome with hypertension: a case report. *Cureus, 11*(5).
11. Banon, S., & Skaribas, I. (2020). Serial ganglion impar blocks in a patient with nutcracker syndrome re-fractory to left renal vein transposition: a case report. *Journal of Medical Case Reports, 14*, 1-4.
12. Banzić, I., Fatić, N., Pejkić, S., Davidović, L., Sladojević, M., & Končar, I. (2016). Case report of gross hematuria in the nutcracker syndrome resolved by renocaval reimplantation. *Vojnosanitetski pregled, 73*(12), 1178-1180.
13. Belczak, S. Q., Neto, F. C., de Araújo, W. J. B., & de Pereira Godoy, J. M. (2020). Endovascular treat-ment of anterior nutcracker syndrome and pelvic varices in a patient with an anterior and a posterior re-nal vein. *BMJ Case Reports CP, 13*(9), e235284.
14. Chung, C. Y., Lytle, M. E., & Clemente Fuentes, R. W. (2021). A Case of Posterior Nutcracker Syndrome Revealed in the Aerospace Environment. *Aerospace Medicine and Human Performance, 92*(1), 54-56.
15. Copetti, R., & Copetti, E. (2017). Renal nutcracker syndrome. *Acta Med Acad, 46*(1), 63-4.
16. Daily, R., Matteo, J., Loper, T., & Northup, M. (2012). Nutcracker syndrome: symptoms of syncope and hypotension improved following endovascular stenting. *Vascular, 20*(6), 337-341.
17. Macedo, G. L. D., Santos, M. A. D., Sarris, A. B., & Gomes, R. Z. (2019). Venous revascularization to treat posterior nutcracker syndrome by transposition of the left gonadal vein: case report. *Jornal Vascu-lar Brasileiro, 18*, e20190037.
18. Devcic, Z., Rozen, T. D., Arora, M., Caserta, M. P., Erben, Y. M., Sandhu, S. S., ... & Toskich, B. B. (2022). Daily persistent headache with nutcracker physiology and spinal epidural venous congestion: Treatment with lumbar vein embolization. *Radiology Case Reports, 17*(11), 4314-4318.
19. Dunphy, L., Penna, M., Tam, E., & Jihene, E. K. (2019). Left renal vein entrapment syndrome: nutcracker syndrome! *BMJ Case Reports CP, 12*(9), e230877.
20. Elhattabi, K., Elbakouri, A., Ouchane, M., Bouali, M., Bensardi, F., & Fadil, A. (2020). Nutcracker syn-drome due to aorto-mesenteric compression in adults: Case report and literature review. *International Journal of Surgery Case Reports, 77*, 730-732.
21. Farina, R., Iannace, F. A., Foti, P. V., Conti, A., Inì, C., Libra, F., ... & Basile, A. (2020). A case of nut-cracker syndrome combined with wilkie syndrome with unusual clinical presentation. *The American Journal of Case Reports, 21,* e922715-1.
22. Genov, P. P., Kirilov, I. V., Hristova, I. A., Kolev, N. H., Dunev, V. R., & Stoykov, B. A. (2020). Manage-ment and diagnosis of Nutcracker syndrome-a case report. *Urology Case Reports, 29,* 101103.
23. Greenspan, J., Szczerepa, D., Trocha, K., Rao, A., Fluss, G., & Finlay, D. (2022). A novel approach for the treatment of Nutcracker Syndrome: A case report. *Annals of Vascular Surgery, 79,* 441-e1.
24. Hansraj, N., Hamdi, A., Khalifeh, A., Wise, E., Sarkar, R., & Toursavadkohi, S. (2017). Nutcracker syn-drome: case report on the management of recurrent stenosis after stenting. *Vascular and Endovascular Surgery, 51*(4), 203-208.
25. Diab, S., & Hayek, F. (2020). Combined superior mesenteric artery syndrome and nutcracker syndrome in a young patient: a case report and review of the literature. *The American Journal of Case Reports, 21,* e922619-1.
26. Heidbreder, R. (2018). Co-occurring superior mesenteric artery syndrome and nutcracker syndrome re-quiring Roux-en-Y duodenojejunostomy and left renal vein transposition: a case report and review of the literature. *Journal of Medical Case Reports, 12,* 1-9.
27. Hori, K., Yamamoto, S., Kosukegawa, M., Yamashita, N., & Shinno, Y. (2022). Nutcracker syndrome as the main cause of left renal vein thrombus and pulmonary thromboembolism. *IJU Case Reports, 5*(1), 24-27.
28. Inal, M., Daphan, B. U., & Bilgili, M. Y. K. (2014). Superior mesenteric artery syndrome accompanying with nutcracker syndrome: a case report. *Iranian Red Crescent Medical Journal, 16*(10).
29. Karami, M., Kouhi, H., Sadatmadani, S. F., Sadeghi, B., Rostamiyan, N., & Hashemzadeh, M. (2021). Splenic vein enlargement, a rare cause of nutcracker syndrome. *Clinical Case Reports, 9*(5), e03833.
30. Miler, R., Shang, E. K., & Park, W. M. (2018). Gonadal vein transposition in nutcracker syn-drome. *Annals of Vascular Surgery, 46,* 205-e13.
31. Muheilan, M., Walsh, A., O'Brien, F., & Tuite, D. (2022). Nutcracker syndrome, conservative approach: a case report. *Journal of Surgical Case Reports, 2022*(10), rjac423.
32. Nakashima, T., Sahashi, Y., Kanamori, H., Ohno, Y., & Okura, H. (2020). Localized solitary left renal vein thrombus complicating nutcracker syndrome: a case report and review of the literature. *CEN Case Reports, 9*, 252-256.
33. Oh, M. J. (2017). Superior mesenteric artery syndrome com-

bined with renal nutcracker syndrome in a young male: a case report. *The Korean Journal of Gastroenterology= Taehan Sohwagi Hakhoe chi, 70*(5), 253-260.
34. Patel, B., & Samuel, S. (2019). Nutcracker Syndrome—An Unusual Case of Chronic Left Upper Ab-dominal Pain: A Case Report. *A&A Practice, 12*(3), 69-72.
35. Quevedo, H. C., Arain, S. A., & Abi Rafeh, N. (2014). Systematic review of endovascular therapy for nutcracker syndrome and case presentation. *Cardiovascular Revascularization Medicine, 15*(5), 305-307.
36. Shi, Y., Shi, G., Li, Z., Chen, Y., Tang, S., & Huang, W. (2019). Superior mesenteric artery syndrome coexists with Nutcracker syndrome in a female: a case report. *BMC gastroenterology, 19,* 1-5.
37. Siddiqui, W. J., Bakar, A., Aslam, M., Arif, H., Bianco, B. A., Trebelev, A. E., ... & Aggarwal, S. (2017). Left renal vein compression syndrome: cracking the nut of clinical dilemmas–three cases and review of literature. *The American journal of case reports, 18,* 754.
38. Steinberg, R. L., Johnson, B. A., Garbens, A., & Cadeddu, J. A. (2020). Robotic assisted extravascular stent placement for nutcracker phenomenon of the left renal vein: a case series. *Journal of robotic sur-gery, 14,* 781-788.
39. Taneja, M., Chua, B. S. Y., & Daga, K. (2018). Renal nutcracker syndrome in a young lady: unusual find-ings and endovascular management. *Case Reports, 2018*, bcr-2017.
40. Viriyaroj, V., Akranurakkul, P., Muyphuag, B., & Kitpornthernanunt, M. (2012). Laparoscopic transperito-neal gonadal vein ligation for treatment of pelvic congestion secondary to Nutcracker syndrome: a case report. *J Med Assoc Thai, 95*(Suppl 12), S142-5.
41. Wang, R. F., Zhou, C. Z., Fu, Y. Q., & Lv, W. F. (2021). Nutcracker syndrome accompanied by hyper-tension: a case report and literature review. *Journal of International Medical Research, 49*(1), 0300060520985733.
42. Yamamoto, A., Kamoi, S., & Suzuki, S. (2021). Spontaneous rupture of the ovarian vein in association with nutcracker syndrome: a case report. *Journal of Medical Case Reports, 15,* 1-6.
43. Yu, S., Hu, H., & Ding, G. (2019). Robot-assisted laparoscopic left renal vein transposition for the treat-ment of nutcracker syndrome: a preliminary experience. *Annals of Vascular Surgery, 57*, 69-74.
44. Stubberud, A., Cheema, S., Tronvik, E., & Matharu, M. (2020). Nutcracker syndrome mimicking new dai-ly persistent headache: a case report. *Cephalalgia, 40*(9), 1008-1011.
45. Bin Dahman, H. A., & Aljabry, A. O. (2019). A case report of a young girl with recurrent hematuria: a missed diagnosis-renal nutcracker syndrome. *BMC nephrology, 20*, 1-5.
46. Amesty, M. V., Rivas, S., Dal Moro, F., & Mancini, M. (2024). Expertise Area 2.4: Rare retroperitoneal diseases and conditions. In *Rare and Complex Urology* (pp. 205-228). Academic Press.