Received: 20 May 2019 | Accepted: 27 July 2019

DOI: 10.1002/nau.24138

ORIGINAL CLINICAL ARTICLE

Neurourology Urodynamics ICS SUFU WILEY

Levator ani muscle injury and risk for urinary and fecal incontinence in parous women from a normal population, a cross-sectional study

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Funding information
The Liasion Committee for Education, Research and Innovation in Central Norway (Samarbeidsorganet - Helse Midt Norge), Grant/Award Number: P-101830-01; Norske Kvinners Sanitetsforening (Norwegian Women`s Public Health Association/the Norwegian Extra Foundation), Grant/Award Number: 2013/FOM 5623

Abstract

Aims: To study possible associations between levator ani muscle (LAM) injury and urinary incontinence (UI) and fecal incontinence (FI) and possible associations between bladder neck descent (BND), urethral funneling, and UI.

Methods: A cross-sectional study of 608 women with first delivery in 1990 to 1997 assessed in 2013 to 2014. The Urinary Distress Inventory (UDI-6) and Colorectal Anal Distress Inventory (CRADI-8) were used to quantify symptoms (range, 0-100). The proportion of women with UI and FI was calculated. LAM injury, BND ≥25 mm, and funneling were diagnosed with transperineal ultrasound. Women with LAM injury, BND, and urethral funneling were compared to those without, using the Mann-Whitney *U* test (symptom scores) and multiple logistic regression analysis (UI and FI).

Results: Four-hundred ninety-three (81%) women had intact LAM and 113 (19%) had LAM injury. They had similar median (range) UDI-6 score 8.3 (0-75) vs 4.2 (0-62.5), $P = .35$, and CRADI-8 score 6.3 (0-78.1) vs 6.3 (0-62.5), $P = .90$. Three hundred eleven out of six hundred (52%) women had UI and 65 of 594 (11%) had FI. This was similar for women with intact vs injured LAM; UI 53% vs 49%, $P = .67$; FI 11% vs 12%, $P = .44$ and with and without BND; stress UI 42% vs 42%, $P = .93$; urge UI 29% vs 35%, $P = .34$. Stress UI was more common in women with urethral funneling (50% vs 40%), odds ratio 1.56 (95% confidence interval: 1.03-2.37), $P = .04$.

Conclusion: We found no associations between LAM injury and symptoms of UI and FI 15 to 24 years after the first delivery, but urethral funneling was associated with stress UI.

KEYWORDS

fecal incontinence, levator ani muscle, pelvic floor, ultrasound imaging, urinary bladder, urinary incontinence

1 | INTRODUCTION

Pelvic floor disorders (PFD) affect a large proportion of adult women with an estimated prevalence of 16% to 69% for urinary incontinence (UI) and 6% to 9% for fecal incontinence (FI) in population-based studies.[1,2] The prevalence of UI and FI increases with advancing age, but the etiology is believed to be multifactorial.[3,4] Pregnancy, vaginal delivery, parity, smoking, and body mass index (BMI) are additional risk factors for developing PFD.[5,6]

The levator ani muscle (LAM) is subjected to excessive tension and stretch during vaginal delivery.[6] Previous studies have demonstrated a strong association between LAM injury, occurring during vaginal delivery, and symptoms and signs of pelvic organ prolapse.[7,8] Loss of bladder neck and urethral support is believed to be important for developing UI.[9] Since LAM injury is closely associated with prolapse in the anterior vaginal wall, it is plausible that this may influence the bladder neck and urethral support. Obstetric anal sphincter tear is strongly associated with the development of FI, but the loss of support to the rectum caused by a LAM injury may also contribute.[10] However, only a few studies have investigated a possible association between LAM injury and FI and UI, and most of them were conducted in the early postpartum period.[8,11,12] There is contrasting evidence regarding the association between LAM injury and UI and FI in later life, and the influence of LAM injury on UI and FI several years after delivery needs to be addressed.[11,13,14]

Previous studies have demonstrated an association between stress urinary incontinence (SUI) and bladder neck descent (BND) and urethral mobility.[9,15] These studies have shown that SUI is associated with urethral hypermobility in urogynecological populations, but women from a normal population have not been examined.[9,15] Loss of bladder neck support can be seen as urethral funneling on ultrasound[16] but any association with UI has been sparsely studied.

Our primary aim was to study a possible association between LAM injury and symptoms of UI and FI in a general population of women 15 to 24 years after first delivery. Our secondary aim was to examine a possible association between BND, urethral funneling, and UI.

2 | MATERIALS AND METHODS

This is a secondary analysis of a cross-sectional study of 608 women with first delivery at Trondheim University Hospital, Norway, between 1 January 1990 and 31 December 1997. The primary aim of this study was to examine differences in PFD and LAM injury after different modes of delivery, and results have been published elsewhere.[5] Women who were still alive and had a postal address in Norway in 2013 were identified from the Hospital Patient Administrative System. All women who underwent operative vaginal and cesarean deliveries from January to December and normal vaginal deliveries from January to July of each calendar year were invited to participate in the study. Following the inclusion criteria of the parent study, participants may have had cesarean delivery after normal or operative vaginal delivery, but no vaginal delivery after cesarean, and no operative vaginal delivery after normal delivery.[5] Exclusion criteria were stillbirth, breech delivery, and infant birth weight less than 2000 g at the index birth. However, they were not excluded if these conditions occurred in subsequent pregnancies. Flowchart of the study population is presented in Figure 1. The study was approved by the Regional Committee for Medical and Health Research Ethics (REK midt 2012/666) and registered in clinicaltrials.gov NCT01766193. Written informed consent was obtained from all study participants.

Information about infant birth weight, parity, and perineal tears was obtained from the Norwegian Medical Birth Registry. All study participants answered a postal questionnaire regarding height, weight, any previous incontinence surgery, and a Norwegian translation of the Pelvic Floor Distress Inventory (PFDI-20).[17] For quantification of symptoms we used the subscores from the

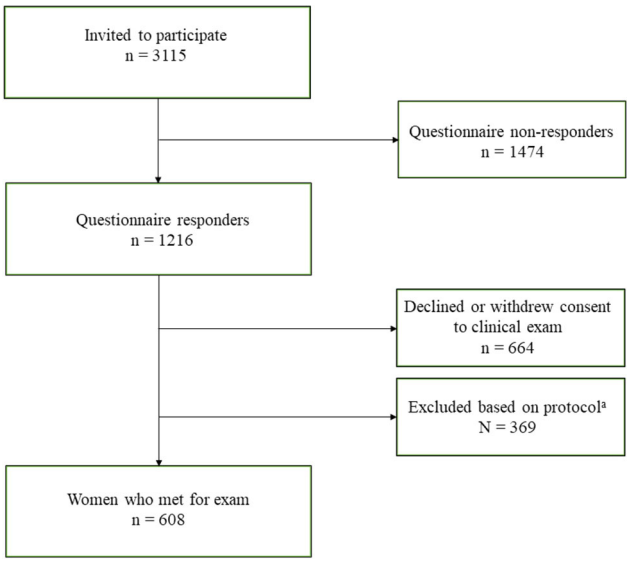

FIGURE 1 Flowchart of the study population.[a] Three-hundred sixty nine women were excluded based on the protocol of parent study[7,19] (due to operative vaginal delivery after a cesarean or normal vaginal delivery or lived too far from Trondheim in 2013 or unable to meet for the exam during inclusion period)

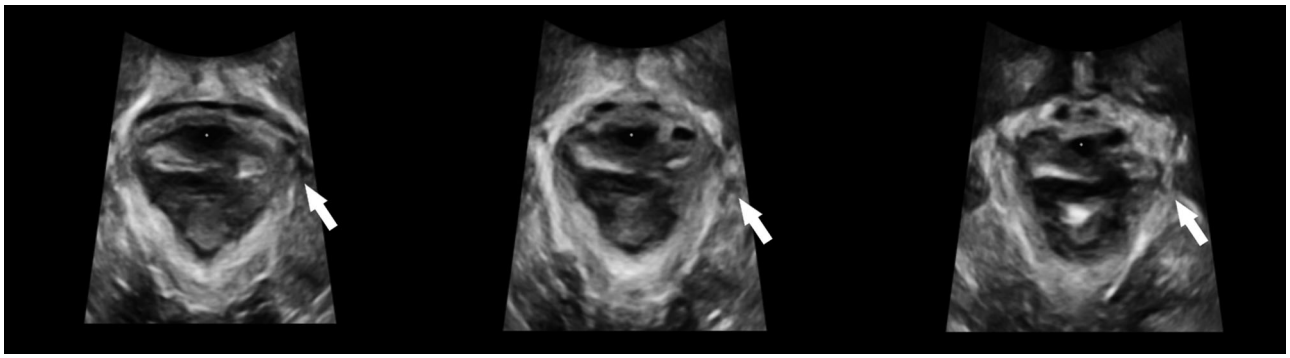

FIGURE 2 Left sided levator ani muscle (LAM) injury (white arrow) on tomographic ultrasound imaging at maximal levator contraction. Intact LAM on the right side

Urinary Distress Inventory (UDI-6) and Colorectal Anal Distress Inventory (CRADI-8), range, 0 to 100.[17] We also registered the proportion of women with urge urinary incontinence (UUI), SUI, and leakage of loose or formed stool, when answering "yes" to the questions: "Do you usually experience urine leakage associated with a feeling of urgency, ie, a strong sensation of needing to go to the bathroom?", "Do you usually experience urine leakage related to coughing, sneezing, or laughing?," "Do you usually loose stool beyond your control if your stool is well-formed?," "Do you usually loose stool beyond your control if your stool is loose?." The proportion of women with any UI or FI was calculated, including women who had undergone any previous incontinence surgery, as some of them were now asymptomatic.

Women living in both urban and rural areas who responded to the questionnaire, who still lived within the referral districts for Trondheim University Hospital and consented to clinical examination, were invited to a clinical exam including transperineal ultrasound (Figure 1). They met with empty urinary bladder and bowel, which was confirmed during the ultrasound examination. They were asked to withhold any information regarding previous deliveries, prolapse and incontinence symptoms, pelvic floor muscle exercise, and gynecological surgery until the examination had been completed. They were examined in the supine position in a gynecological examination chair, with knees and hips semiflexed and abducted. Three-dimensional (3D)/4D ultrasound volumes of the pelvic floor and anal sphincter muscles were acquired with a GE Voluson S6 device (GE Medical Systems, Zipf, Austria) using the RAB 4-8RS abdominal 3D probe and acquisition angle of 85°. Three volumes were acquired during pelvic floor muscle contraction and at Valsalva.

Offline analysis of the ultrasound volumes was performed 6 to 24 months after the ultrasound scan on a computer using the 4D view Version 14 Ext.0 (GE Healthcare, Austria) software, blinded to all clinical data. Tomographic ultrasound imaging was used to identify significant LAM injury at pelvic floor muscle contraction. A significant LAM injury was diagnosed if all three central slices; the slice in the plane of minimal hiatal dimensions and the slices 2.5 and 5.0 mm cranial to this, showed abnormal muscle insertion (Figure 2).[18] Injury was diagnosed as unilateral or bilateral, and the number of women with significant levator injury (unilateral or bilateral) was registered. A defect of the external or internal anal sphincter of ≥30° in at least four of six slices on tomographic ultrasound imaging was considered a significant defect.[19] BND was assessed in the midsagittal view, see Figure 3. A horizontal line was drawn from the posterior-inferior margin of the pubic symphysis, and the distance from the bladder neck to this horizontal line was measured at rest and Valsalva. BND was calculated as the

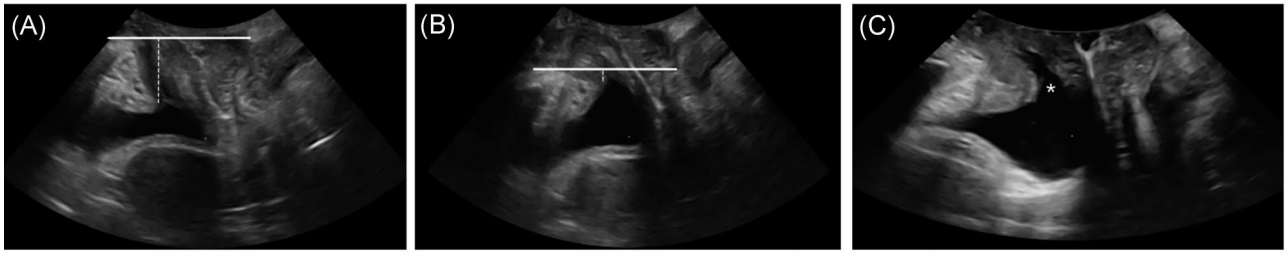

FIGURE 3 Bladder neck descent is measured as the difference between (A) rest and (B) Valsalva. The horizontal solid line is drawn through the inferior-posterior level of the symphysis pubis and the dashed vertical lines show the distance to the bladder neck. (C) Urethral funneling (asterisk) is seen as a dilatation of the proximal urethra at Valsalva

difference between rest and at maximum Valsalva. Earlier studies have suggested that SUI is associated with BND ≥25 mm, hence we used this value as a cut off for significant BND.[9] Finally, the number of women displaying urethral funneling, ie, dilatation of the proximal urethra at the urethrovesical junction during Valsalva, was noted, see Figure 3.[16]

2.1 | Statistical analyses

We used SPSS version 25 (SPSS Inc, Chicago, IL) to perform statistical analysis and $P < .05$ was considered statistically significant. The symptom scores were not normally distributed. The Mann-Whitney *U* test was used to compare symptoms between women with injured (unilateral or bilateral) and intact LAM. We performed a subanalysis comparing women with bilateral injury to those with intact LAM. A multiple logistic regression analysis was used to calculate the adjusted odds ratio (aOR) for SUI, UUI, and any UI (including previous surgery) comparing women with intact and injured LAM, adjusting for age, BMI, parity, infant birth weight, and cystocele (≥stage 2). Multiple logistic regression analysis was also used to calculate the aOR for FI (including previous surgery) for women with injured vs intact LAM adjusting for the variables above (except cystocele) and any significant external or internal anal sphincter defect on ultrasound. Furthermore, we calculated the aOR for UUI and SUI for women with and without significant BND and urethral funneling with multiple logistic regression, adjusting for age, BMI, parity, and infant birth weight. Possible confounders were selected based on results from previous studies and clinical experience.[7,19]

3 | RESULTS

In all, 608 women were examined. Mean (standard deviation) age was 47.9 years (4.9), BMI was 25.8 kg/m^2 (4.5), parity was 2.2 (0.8), birth weight of the largest infant was 3861g (506). Overall, 217 of 608 (36%) women had a normal delivery, 290 of 608 (47%) had an operative vaginal delivery and 101 of 608 (17%) women had delivered by cesarean section only. Compared to women who declined examination, the women examined were slightly older 47.3 vs 47.9 years ($P < .01$) and had more UI 46.9% vs 51.8% ($P = .04$) but not FI 9.1% vs 10.9% ($P = .2$) and were similar regarding parity, BMI, mode of delivery, and infant birth weight.

A significant external or internal anal sphincter defect was found in 86 (15.3%) women. In total, 493 (81%) women had intact LAM and 113 (19%) had LAM injury, of which 57 (9%) were bilateral. For two women LAM injury was not possible to determine. We found that 311 of 600 (52%) had UI or previous surgery and 65 of 594 (11%) had FI or previous surgery. The mean (SD) and median (range) UDI-6 and CRADI-8 scores, and the proportions of women with UI, FI, or previous surgery are presented in Table 1. Both the median UDI-6 and CRADI-8 scores and the proportion of women with UI and FI were similar for women with intact and injured LAM. A subanalysis of women with bilateral LAM injury did not change the results. None of the selected confounders, except BMI, were associated with UI (Table 1). Anal sphincter defect was the only risk factor associated with FI (Table 1).

BND and urethral funneling were available for assessment in 582 women, and the associations with SUI and UUI are shown in Table 2. Fifty percent of the women with urethral funneling had SUI, and urethral funneling was significantly associated with SUI (aOR, 1.56 [95% confidence interval, 1.03-2.37)]; $P = .04$). A similar trend was seen for BND, but this difference was not statistically significant. BND and urethral funneling were not associated with UUI. BMI was associated with UUI and SUI (Table 2).

4 | DISCUSSION

This cross-sectional study showed no association between LAM injury and UI or FI in parous women recruited from a normal population 15 to 24 years after the first delivery. The results remained unchanged in a sub-analysis of women with bilateral LAM injuries. However, we found that urethral funneling was associated with SUI.

LAM injuries usually occur during the first delivery,[6] whereas UI and FI are diagnosed years later. One strength of this study is a long time interval between the first delivery and assessment of symptoms.[5,7,19] Another strength is that women were recruited from the normal population, ensuring that the results are relevant for parous women in general, and not only for patient populations. Evaluation of ultrasound volumes was blinded, since the examiner was unaware of the obstetric history and any PFD symptoms. Detailed analyses of symptoms were performed using both symptom scores and a positive response to single questions and previous incontinence surgery. A subanalysis comparing women with bilateral LAM injury and women with intact LAM made it possible to study if a more severe pelvic floor injury had a greater impact on symptoms.

TABLE 1 Symptom scores and prevalence of stress urinary incontinence, urge urinary incontinence, and fecal incontinence according to intact and injured levator ani muscle

	Mean (SD) Median (range)			Mann-Whitney *U* test, *P*	
	Intact LAMN = 492	Any LAM injury (uni- or bilateral) N = 113	Bilateral LAM injury N = 57	Any LAM injury vs intact LAM	Bilateral LAM injury vs intact LAM
Urinary Distress Inventory (UDI-6)	12.9 (16.0)	11.3 (14.8)	12.0 (15.5)	0.35	.53
Range, 0-100	8.3 (0-75)	4.2 (0-62.5)	4.2 (0-58.3)		
Colorectal Anal Distress Inventory (CRADI-8)	13.3 (15.8)	12.6 (14.9)	10.8 (10.9)	0.90	.75
Range, 0-100	6.3 (0-78.1)	6.3 (0-62.5)	6.3 (0-40.6)		
	Number/total(%)			aOR (95% CI), *P*	
UUI	155/486	30/111	17/56	0.86 (0.5-1.4)	1.1 (0.6-1.9)
	(31.9)	(27.0)	(30.4)	0.54	.88
SUI	214/491	42/111	20/56	0.8 (0.5-1.2)	.8 (0.4-1.4)
	(43.6)	(37.8)	(35.7)	0.32	.42
Any UI or surgery[a]	256/488	54/110	25/56	0.9 (0.6-1.4)	.8 (0.5-1.4)
	(52.5)	(49.1)	(44.6)	0.67	.44
FI	51/492	13/113	3/57	0.7 (0.3-1.5)	.3 (0.1-1.0)
	(10.4)	(11.5)	(5.3)	0.32	.06
FI or surgery[b]	52/482	13/111	3/57	0.7 (0.3-1.5)	.3 (0.1-1.0)
	(10.8)	(11.7)	(5.3)	0.32	.05

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; FI, fecal incontinence; LAM, levator ani muscle; SUI, stress urinary incontinence; UI, urinary; UUI, urge urinary incontinence.

[a]BMI was associated with UUI, SUI and any UI or surgery, aOR, 1.1 (1.0-1.1), $P < .001$.

[b]Any anal sphincter defect was associated with FI, aOR, 3.5 (1.6-7.5), $P < .01$, and FI or surgery, aOR, 3.4 (1.5-7.3), $P < .01$.

Since this is a cross-sectional study, we cannot determine causality. One limitation was that the population consisted of a large proportion of women with operative vaginal deliveries, due to the design of the parent study. Instrumental delivery has been associated with an increased risk for anal sphincter defects and LAM injury as shown in earlier studies.[5,19] Since operative vaginal deliveries are associated with PFDs this study population could be more symptomatic than the normal population they were recruited from. We also acknowledge that this study was performed in a homogenous Caucasian population and may not be representative of other ethnic groups. Pelvic floor muscle training can influence UI symptoms.[20] Some women in this study population may have received physiotherapy counseling, which may have alleviated symptoms. Furthermore, women with symptoms may be more willing to participate in studies, and this may introduce possible selection bias in the study. We had no information about

TABLE 2 Prevalence of urinary incontinence among women with and without bladder neck descent and urethral funneling

	Bladder neck descent number/total (%)			Urethral funneling number/total (%)		
	Yes	No	aOR (95% CI) *P*	Yes	No	aOR (95% CI) *P*
SUI[a]	154/363	95/224	1.0 (0.7-1.4)	58/117	191/470	1.6 (1.03-2.4)
N = 249	(42%)	(42%)	0.93	(50%)	(41%)	0.04
UUI[b]	106/360	77/222	0.8 (0.6-1.2)	34/116	149/466	0.9 (0.6-1.5)
N = 183	(29%)	(35%)	0.34	(29%)	(32%)	0.78

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; SUI, stress urinary incontinence; UUI, urge urinary incontinence.

[a]BMI was associated with SUI, aOR, 1.1 (1.0-1.1), $P < .01$.

[b]BMI was associated with UUI, aOR, 1.1 (1.0-1.1), $P < .001$.

neuromuscular disorders that can contribute to the development of FI and UI.

Intact musculature is important for the support of the anterior vaginal wall, and some authors have suggested that muscle injury may have an impact on the support of the urethra and bladder neck.[8] If this is correct, we could expect that LAM injury was associated with SUI, however, this was not demonstrated. One possible explanation could be that an anterior wall prolapse camouflages the symptoms due to a kinking of the urethra, and a previous publication found a high prevalence (45%) of pelvic organ prolapse stage 2 among these women.[7] Therefore, some women may have occult UI, which may become evident after prolapse treatment. Thus, an underestimation of an association between LAM injury and UI is possible. In this study, however, including cystocele as a factor in the analysis, did not change the results. BND may be associated with anterior wall prolapse, and it is therefore not surprising that we found no association with UI.[9] Previous studies using magnetic resonance imaging and ultrasound have reported a decreased prevalence of UI among women with major LAM defects.[13,21] A true association between LAM defects and UI might be difficult to assess unless a follow-up study of women undergoing treatment for pelvic organ prolapse is performed. The continence mechanism is, however, complex, and it seems that other factors, such as BMI, intrinsic urethral closure pressure, hormonal changes, and pelvic floor muscle exercise, and strength may be more important than LAM injury. DeLancey et al[22] found that maximal urethral closure pressure strongly correlated with SUI. Urethral closure pressure is dependent upon the action of mucosal turgor, smooth, and striated muscles, which in turn decreases due to age-dependent striated muscle loss.[22,23] These findings agree with previous studies demonstrating no association between LAM injury and UI.[21,24]

Interestingly, urethral funneling was associated with SUI. This is consistent with other studies which relate funneling and length of the urethral sphincter with the type of incontinence.[25] Ultrasound parameters like urethral funneling may provide physicians with additional information about the incontinence mechanism for women with UI. However, further studies are needed to establish if urethral funneling is a risk factor for UI after prolapse surgery. Studies are also needed to address if LAM injury is a risk factor for UI after surgical correction of anterior wall prolapse.

Previous studies have identified obstetric anal sphincter injuries as the main risk factor for FI after delivery.[19] In this study, we found a strong association between FI and anal sphincter defects on ultrasound, consistent with those studies.

5 | CONCLUSION

In this study of parous women examined 15 to 24 years after first delivery we found that LAM injury was not associated with UI or FI. Although LAM injury results in decreased support of the anterior vaginal wall, other factors seem more relevant as contributors to the complex etiology of incontinence. Urethral funneling was associated with SUI. Further studies are needed to establish if LAM injury is a risk factor for the development of UI after prolapse surgery.

ACKNOWLEDGMENTS

We thank Guri Kolberg for coordination of clinical examinations, Johan Morten Dreier, and Berit Marianne Bjelkaasen for support with questionnaires. We thank Trondheim University Hospital and the Norwegian University of Science and Technology for providing the necessary infrastructure. Tuva K Halle and Christine Østerli for help in identifying potential study participants. This study was funded by the Norwegian Women's Public Health Association/the Norwegian Extra Foundation, and The Liaison Committee for Education, Research, and Innovation in Central Norway. The funding sources had no role in study design, data collection, analysis, interpretation, or article formation.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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How to cite this article: Mathew S, Guzmán Rojas R, Salvesen K, Volløyhaug I. Levator ani muscle injury and risk for urinary and fecal incontinence in parous women from a normal population, a cross-sectional study. *Neurourology and Urodynamics*. 2019;38:2296-2302. https://doi.org/10.1002/nau.24138