ORIGINAL ARTICLE

Proportion of femoral hernia repairs performed for recurrence in the United States

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Abstract

Purpose Recurrence rates after femoral hernia repair (FHR) have not been reliably established in the USA. We sought to determine this trend over time.

Methods The proportion of primary and recurrent FHRs was determined for patients age $\geq$ 18 from: ACS-NSQIP (1/2005–12/2014), Premier (1/2010–09/2015), and institutional (1/2005–12/2014) data. Trends were analyzed using a one-tailed Cochran–Armitage test.

Results In the NSQIP database, 6649 patients underwent a FHR. In females, the proportion of FHRs performed for recurrence decreased from 14.0% in 2005 to 6.2% in 2014, $p = 0.02$. In males, there was no change: 16.7–16.1% 2005–2014 ($p = 0.18$). The Premier database included 4495 FHRs and our institution 315 FHRs. There was no difference for either gender over time in either data source, all $p > 0.05$.

Conclusions The proportion of femoral hernia repairs performed for recurrence in the USA remained relatively constant in males in two large national databases between 2005 and 2015. In females, a decrease was seen in one of the large national databases.

Keywords Femoral hernia repair · Recurrence · NSQIP · Premier

Introduction

In comparison with inguinal hernias, femoral hernias are uncommon, accounting for 2–4% of groin hernia repairs [1–4]. Approximately 30,000 femoral hernia repairs (FHR) are performed annually in the United States [5]. In contrast to inguinal hernias, femoral hernias are more likely to require emergent repairs and are associated with a higher complication rate and morbidity [6–8]. Therefore, although rare, identifying the risk and risk factors of recurrence following FHR in this patient population is of great importance.

Currently, there is a paucity of consistent data regarding the recurrence rate following groin hernia repairs, especially

FHRs in the United States [9]. Around the world, the recurrence rate after FHR ranges from 0 to 6.1% for primary repairs and increases after previous repair [2–4, 7, 10–15]. In Sweden, this reported rate has been decreasing since 1984 and was approximately 2–3% in 1994 [4]. In the United States, while reported recurrence rates vary between 0 and 3%, [16, 17] the majority of these studies are outdated or are composed of small sample sizes with limited follow-up and do not adequately assess the state of FHR across the USA as a whole. To assess the current state of FHRs throughout the USA, we evaluated the proportion of FHRs performed for recurrence and the associated trends over time using national databases and data from our multi-site academic medical center.

Materials and methods [9]

Following Institutional Review Board approval, all patients age $\geq$ 18 years who underwent FHR were identified from three sources: American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database, the Premier database, and institutional data. The NSQIP

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database was composed of between 121 and 517 hospitals during the study period of January 1, 2005–December 31, 2014. The Premier database was composed of data from over 600 US hospitals during the study period of January 1, 2010–September 30, 2015. Our institutional data included three Mayo Clinic academic sites (Rochester, MN; Scottsdale, AZ; Jacksonville, FL) and were evaluated between January 1, 2005 and December 31, 2014. Patients were identified using International Classification of Disease-9th Revision (ICD-9) post-operative diagnoses (ICD-9 551.0X, 552.0X, 553.0X) and surgical procedure codes (ICD-9 53.21, 53.29, 53.31, 53.39) or Current Procedural

Terminology (CPT) codes (CPT 49,550, 49553, 49555, 49557). Post-operative diagnoses were selected, as they are available in the large national databases. For inclusion, NSQIP and institutional patients were required to have a CPT for FHR or primary (NSQIP) or any (institutional) post-operative ICD-9 diagnosis code for FHR with concomitant CPT procedure code 49659. Premier patients were required to have a primary post-operative ICD-9 diagnosis of FHR and either (1) CPT for FHR or (2) DRG 350–352 and ICD-9 procedure for FHR.

Comorbidities including diabetes (ICD-9: 250.XX) and chronic obstructive pulmonary disease (COPD; ICD-9: 496)
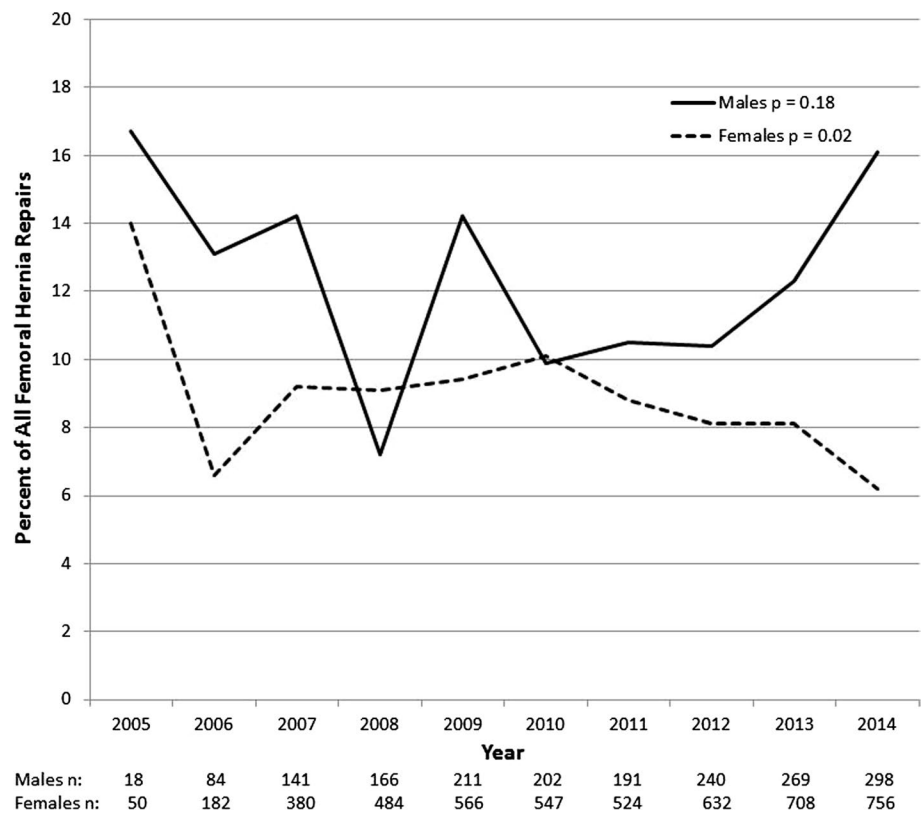
Table 1 Patient and treatment characteristics from NSQIP and Mayo patients

Recurrent Characteristics	*NSQIP						Mayo					
	Total	No		Yes		p value	Total	No		Yes		p value
	N	%	N	%	N	%	N	%	N	%	N	%
Age group						0.40						0.43
18–34	335	5.0	312	5.2	23	3.7	12	3.8	10	3.5	2	6.9
35–44	570	8.6	516	8.6	54	8.6	8	2.5	6	2.1	2	6.9
45–54	1039	15.6	942	15.6	97	15.4	42	13.3	37	12.9	5	17.2
55–64	1139	17.1	1019	16.9	120	19.1	46	14.6	44	15.4	2	6.9
65–74	1265	19.0	1138	18.9	127	20.2	71	22.5	65	22.7	6	20.7
> 74	2301	34.6	2093	34.8	208	33.1	136	43.2	124	43.4	12	41.4
Gender						< 0.001						0.33
Female	4829	72.6	4422	73.5	407	64.7	210	66.7	193	67.5	17	58.6
Male	1820	27.4	1598	26.5	222	35.3	105	33.3	93	32.5	12	41.4
Admission type						0.020						0.040
Emergency	3422	51.5	3126	51.9	296	47.1	122	38.7	116	40.6	6	20.7
Elective	3227	48.5	2894	48.1	333	52.9	193	61.3	170	59.4	23	79.3
Bilateral						0.53						0.71
No	4366	97.3	3963	97.3	403	97.8	293	93.0	265	92.7	28	96.6
Yes	119	2.7	110	2.7	9	2.2	22	7.0	21	7.3	1	3.4
Inpatient vs outpatient						0.090						0.10
Inpatient	2918	43.9	2622	43.6	296	47.1	132	41.9	124	43.4	8	27.6
Outpatient	3731	56.1	3398	56.4	333	52.9	183	58.1	162	56.6	21	72.4
COPD						0.97						1.00
No	6065	91.2	5491	91.2	574	91.3	298	94.6	270	94.4	28	96.6
Yes	584	8.8	529	8.8	55	8.7	17	5.4	16	5.6	1	3.4
Diabetes						0.005						1.00
No	6341	95.4	5727	95.1	614	97.6	304	96.5	276	96.5	28	96.6
Yes	308	4.6	293	4.9	15	2.4	11	3.5	10	3.5	1	3.4
Obesity						0.040						
No	5706	90.7	5175	90.9	531	88.4						
Yes	587	9.3	517	9.1	70	11.6						
Smoker						0.064						
No	5334	80.2	4847	80.5	487	77.4						
Yes	1315	19.8	1173	19.5	142	22.6						

* Missing (var (*n*)): Bilateral (2164), Obesity (356)

COPD chronic obstructive pulmonary disease

Fig. 1 Proportion of femoral hernia repairs performed for recurrence—NSQIP database. *NSQIP* National surgical quality improvement program

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Males n:	18	84	141	166	211	202	191	240	269	298
Females n:	50	182	380	484	566	547	524	632	708	756

were identified by ICD-9 diagnosis codes in Premier and institutional databases; in the NSQIP database these comorbidities were identified using database-specific variables DIABETES and HXCOPD. Obesity was defined as body mass index (BMI) ≥ 30 in our NSQIP and institutional data. In the Premier data, obesity was identified by ICD-9 diagnosis codes (278.0, 278.00, 278.01). Cases were classified as an emergent repair based on the presence of NSQIP-defined emergent status (NSQIP only), ASA class 5 (NSQIP only), ventilator dependence, preoperative SIRS, sepsis, or septic shock, current pneumonia, wound infection, acute renal failure, any perioperative blood transfusion of at least 1 unit red blood cells, coma, disseminated cancer, or ICD-9 diagnosis code for gangrenous (551.0X) or obstructed (552.0X) hernia. Pregnant patients (identified by ICD-9 codes: 640–649, 650–659, V22, V23 or V28) and those undergoing robotic repair (ICD-9 codes: 17.4x, CPT: S2900) were excluded from the study.

The incidence of primary (CPT 49550 49553) and recurrent (CPT 49555 49557) FHRs was evaluated in all data sources, stratified by sex. If a FHR CPT code did not indicate primary or recurrent hernia repair (CPT 49659), ICD-9 diagnoses were used to indicate primary (551.00, 551.02, 552.00, 552.02, 553.00, 553.02) or recurrent (551.01, 551.03, 552.01, 552.03, 553.01, 553.03) repair. To be coded as s recurrent FHR, the prior repair should be a FHR on the ipsilateral side. ICD-9 diagnoses were also used to indicate

bilateral (551.02, 551.03, 552.02, 552.03, 553.02, 553.03) or unilateral (551.00, 551.01, 552.00, 552.01, 553.00, 553.01) FHR.

Patient demographics, comorbidities, and surgical factors were compared using χ^2 and Fisher's exact tests, as appropriate. Trends over time were evaluated for a decrease using a one-tailed Cochran–Armitage test. Statistically significant and clinically relevant variables from the univariate analysis were analyzed by multivariable logistic regression for association with recurrent versus initial FHR. For analyses where sex was found to be statistically significant over time on univariate analysis, we tested for an interaction between sex and year of operation to determine if sex stratification on multivariable analysis was necessary. Outcomes of the multivariable models were reported as odds ratio (OR) with associated 95% confidence interval (CI). Obesity and smoking status were not able to be obtained for institutional data and were, therefore, not adjusted for on logistic regression analysis. Statistical significance was defined as $p < 0.05$. For unadjusted and adjusted logistic regression analyses, missing data were handled with indicator variables (bilateral repair; NSQIP [$n = 2164$], obesity; NSQIP [$N = 356$]). Missing data were not included for univariate proportional analyses. All statistical analyses were performed using SAS Version 9.3 (SAS Institute Inc., Cary NC). These methods have been previously described in a prior study focused on recurrence rates following inguinal hernia repair [9].

Table 2 Univariate and multivariable analysis of NSQIP data sources

	NSQIP univariate analysis			NSQIP multivariable male analysis			NSQIP multivariable female analysis		
	Odds ratio	95% CI		Point estimate	95% CI		Point estimate	95% CI	
Operation year									
	0.98	0.95	1.01	1.029	0.971	1.090	0.958	0.919	0.998
Age									
Age 18–34 vs > 74	0.74	0.48	1.16						
Age 35–44 vs > 74	1.05	0.77	1.44						
Age 45–54 vs > 74	1.04	0.81	1.33						
Age 55–64 vs > 74	1.19	0.94	1.50						
Age 65–74 vs > 74	1.12	0.89	1.42						
Age 35–44 vs 18–34				1.120	0.444	2.829	1.620	0.865	3.032
Age 45–54 vs 18–34				1.404	0.647	3.045	1.386	0.759	2.531
Age 55–64 vs 18–34				1.467	0.683	3.152	1.708	0.944	3.089
Age 65–74 vs 18–34				1.798	0.843	3.836	1.426	0.784	2.593
Age > 74 vs 18–34				1.785	0.839	3.798	1.293	0.716	2.335
Gender female vs male	0.66	0.56	0.79						
Emergency yes vs no	0.82	0.70	0.97	0.735	0.514	1.051	0.706	0.546	0.912
Bilateral yes vs no	0.81	0.41	1.60	0.261	0.035	1.955	1.072	0.510	2.254
Bilateral unknown vs no	1.10	0.92	1.30	0.932	0.673	1.291	0.895	0.703	1.140
Diabetes yes vs no	0.48	0.28	0.81	0.163	0.051	0.520	0.680	0.373	1.239
Obesity yes vs no	1.32	1.01	1.72	0.977	0.582	1.639	1.478	1.074	2.034
Obesity unknown vs no	0.83	0.56	1.24	0.700	0.342	1.431	0.884	0.542	1.443
COPD yes vs no	1.00	0.74	1.33	0.725	0.432	1.218	1.053	0.724	1.532
Smoker yes vs no	1.21	0.99	1.47	1.156	0.820	1.628	1.190	0.913	1.550
Inpatient vs outpatient	1.15	0.98	1.36	1.416	1.007	1.992	1.422	1.090	1.856

COPD chronic obstructive pulmonary disease

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Results

NSQIP database

In the NSQIP database, 6649 FHR patients (72.6% female) underwent FHR. Patient characteristics are reported in Table 1. In females, the proportion of FHRs performed for recurrence decreased over the study period from 14.0% in 2005 to 6.2% in 2014 ($p = 0.02$). In males, there was no change over time: the proportion performed for recurrence was 16.7% in 2005 and 16.1% in 2014 ($p = 0.18$, Fig. 1).

On univariate analysis, evaluation of year of operation, age, bilateral versus unilateral repair (or unknown), COPD,

smoking status, and inpatient versus outpatient admission were not statistically significant for an association with performance of FHR performed for recurrence. Females (OR 0.66, 95% CI 0.56–0.79), emergent repair (OR 0.82, 95% CI 0.70–0.97), and diabetics (OR 0.48, 95% CI 0.28–0.81) had a decreased likelihood of repair for recurrence. Obesity was the only variable that reached statistical significance for an increased risk of patients needing to undergo FHR for recurrence (OR 1.32, 95% CI 1.01–1.72), Table 2.

Females were found to have a significant decrease in FHR over the study period on univariate analysis; therefore, our multivariable analysis was tested for an interaction between years (as a continuous variable) and sex. Due to the finding of a statistically significant interaction ($p = 0.04$), we stratified our NSQIP data by sex. When stratified by sex, in females, year of operation (OR 0.96, 95% CI 0.919–0.998) and emergent operation (OR 0.71, 95% CI 0.55–0.92) were associated with a decrease of the proportion of recurrent FHRs, while obesity (OR 1.48, 95% CI 1.07–2.03) and inpatient admission (OR 1.42, 95% CI 1.09–1.86) were associated with an increased likelihood. In males, diabetics were

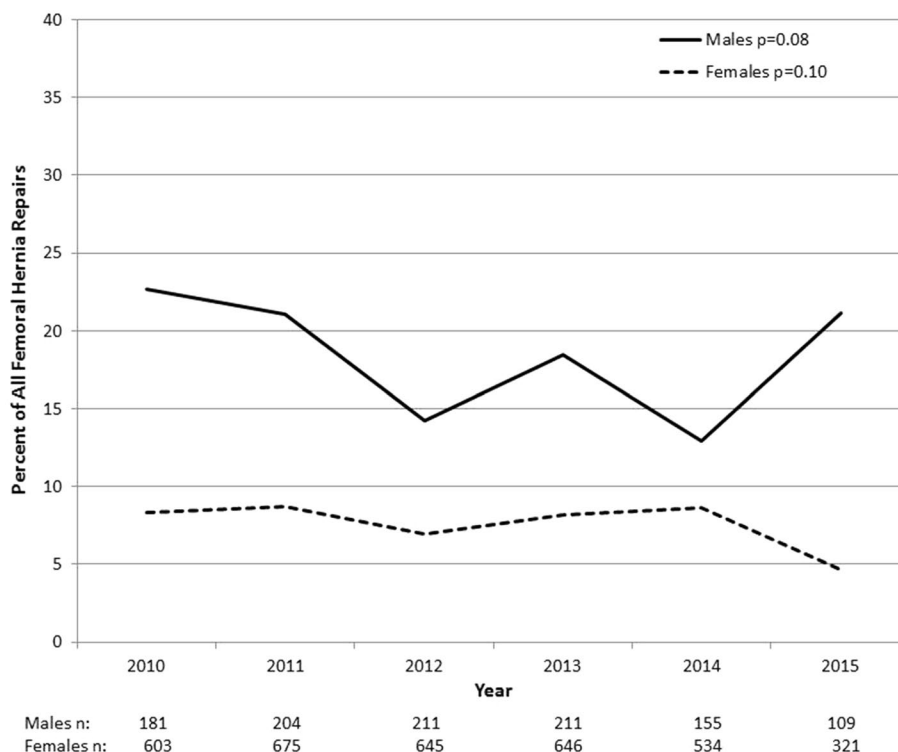**Table 3** Patient and hospital characteristics of Premier database

Recurrent Characteristics	Total N	%	No N	%	Yes N	%	P value
Age group							0.55
18–34	164	3.65	149	3.70	15	3.23	
35–44	315	7.01	286	7.10	29	6.25	
45–54	576	12.81	511	23.68	65	14.01	
55–64	720	16.01	639	15.85	81	17.46	
65–74	900	20.02	799	19.82	101	21.77	
Over 74	1820	40.49	1647	40.86	173	37.28	
Gender							< 0.0001
Female	3424	76.17	3156	78.29	268	57.76	
Male	1071	23.83	875	21.71	196	42.24	
Admission type							< 0.0001
Emergency	2445	54.39	2290	56.81	155	33.41	
Elective	2050	45.61	1741	43.19	309	66.59	
Bilateral							0.78
No	4400	97.89	3945	97.87	455	98.06	
Yes	95	2.11	86	2.13	9	1.94	
Inpatient vs outpatient							< 0.0001
Inpatient	4031	89.68	2092	51.90	146	31.46	
Outpatient	464	10.32	1939	48.10	318	68.54	
COPD							0.47
No	3605	80.20	3227	80.05	378	81.47	
Yes	890	19.80	804	19.95	86	18.53	
Diabetes							0.056
No	4209	93.64	3765	93.40	444	95.69	
Yes	286	6.36	266	6.60	20	4.31	
Obesity							0.60
No	4402	97.93	3949	97.97	453	97.63	
Yes	93	2.07	82	2.03	11	2.37	
Smoker							0.93
No	3830	85.20	3434	85.19	396	85.34	
Yes	665	14.80	597	9.11	68	14.65	
Teaching hospital							0.61
No	3014	67.05	2698	66.93	316	68.10	
Yes	1481	32.95	1333	33.07	148	31.90	
Urban vs rural hospital							0.42
Rural	727	16.17	658	16.32	69	14.87	
Urban	3768	83.83	3373	83.68	395	85.13	
Hospital bed sizes							0.37
< 200 beds	1043	23.20	943	23.39	100	21.55	
200–399 beds	1790	39.82	1611	39.97	179	38.58	
≥ 400 beds	1662	36.98	1477	36.64	185	39.87	

COPD chronic obstructive pulmonary disease

associated with a decreased likelihood of having a repair for recurrence (OR 0.16, 95% CI 0.05–0.52) while inpatient admission (OR 1.42, 95% CI 1.01–1.99) was associated with an increased likelihood. Year of operation, age, emergent repair, unilateral versus bilateral repair, obesity, COPD, and smoking status did not reach statistical significance (all p > 0.05), Table 2.

Fig. 2 Proportion of femoral hernia repairs performed for recurrence—Premier database

	2010	2011	2012	2013	2014	2015
Males n:	181	204	211	211	155	109
Females n:	603	675	645	646	534	321

Premier database

The Premier database contained data on 4495 (76.2% female) FHRs. The majority of patients undergoing FHR were ≥ 65 (60.5%) years of age, Table 3. In contrast to the NSQIP database, there was no significant difference over time for the proportion of FHR performed for recurrence in either sex. In females, 8.3% of repairs were performed for recurrence in 2010 and 4.7% in 2015 ($p = 0.10$). In males, the rate was 22.6% in 2010 and 21.1% in 2015 ($p = 0.08$), Fig. 2.

On univariate analysis, evaluation of year of diagnosis, age, bilateral repair, teaching institution, urban versus rural hospital location, geographic location within the United States, and hospital bed size were not statistically significant for an increased or decreased likelihood of undergoing a FHR for recurrence. Females (OR 0.38, 95% CI 0.30–0.46), patients undergoing emergent repair (OR 0.36, 95% CI 0.29–0.44), and diabetics (OR 0.60, 95% CI 0.37–0.98) had a decreased likelihood of undergoing repair for recurrence (Table 4).

Multivariable analysis showed that year of diagnosis, inpatient (versus outpatient) admission, bilateral repair, obesity, COPD, and smoking status did not increase or decrease the risk of undergoing a FHR for recurrence. Female sex (OR 0.38, 95% CI 0.31–0.47), those undergoing emergent repair (OR 0.45, 95% CI 0.32–0.62), and diabetics (OR 0.62, 95% CI 0.38–1.00) again had a decreased

likelihood of undergoing repair for recurrence. Patients over age 74 (versus 18–24) were more likely to undergo a repair for recurrence (OR 1.41, 95% CI 0.47–4.19); this was the only age group to reach statistical significance (Table 4).

Institutional data

Within our institution, 315 patients (66.7% female) underwent FHR during the study period, Table 1. There was no difference for the proportion of FHRs performed over time for recurrence in either sex (females 0% in 2005 and 2014, $p = 0.14$; males 0% in 2005 to 15.4% ($n = 2$) in 2014, $p = 0.15$); however, we were underpowered as only 17 recurrent repairs occurred for females (and 12 for males) during the study period (Fig. 3).

On univariate analysis, emergent repair was the only variable to reach statistical significance, and was associated with a decreased likelihood of repair for recurrence (OR 0.38, 95% CI 0.15–0.97), Table 5. No variables reached statistical significance on multivariable analysis; Table 5.

Discussion

Through evaluation of two national databases, we showed that the proportion of FHRs performed for recurrence has been decreasing in females in the NSQIP database, while

Table 4 Univariate and multivariable analysis from the Premier database

	Univariate analysis			Multivariable analysis		
	Odds ratio	95% CI		Point estimate	95% CI	
Operation year	0.95	0.90	1.02			
2011 vs 2010				1.00	0.73	1.36
2012 vs 2010				0.73	0.52	1.02
2013 vs 2010				0.90	0.66	1.24
2014 vs 2010				0.83	0.58	1.17
2015 vs 2010				0.77	0.51	1.16
Age						
Age 18–34 vs over 74	0.69	0.39	1.24			
Age 35–44 vs over 74	0.68	0.44	1.06			
Age 45–54 vs over 74	0.84	0.60	1.17			
Age 55–64 vs over 74	0.91	0.67	1.23			
Age 65–74 vs over 74	0.99	0.75	1.31			
Age 25–34 vs 18–24				0.87	0.25	3.03
Age 35–44 vs 18–24				0.87	0.29	2.72
Age 45–54 vs 18–24				1.11	0.37	3.35
Age 55–64 vs 18–24				1.18	0.39	3.53
Age 65–74 vs 18–24				1.36	0.45	4.06
Over 74 vs 18–24				1.41	0.47	4.19
Gender female vs male	0.38	0.30	0.46	0.38	0.31	0.47
Emergency yes vs no	0.36	0.29	0.44	0.45	0.32	0.62
Bilateral yes vs no	0.72	0.35	1.46	0.76	0.37	1.54
Diabetes yes vs no	0.60	0.37	0.98	0.62	0.38	1.00
Obesity yes vs no	1.44	0.74	2.80	1.48	0.76	2.85
COPD yes vs no	0.94	0.72	1.22	0.98	0.74	1.25
Smoking yes vs no				0.96	0.72	1.28
Inpatient vs outpatient				0.77	0.55	1.09
Teaching hospital vs no	0.83	0.65	1.06			
Rural vs urban	0.89	0.66	1.12			
Hospital size						
Bed size 200–399 vs ≥ 400 beds	0.83	0.65	1.05			
Bed size < 200 vs ≥ 400 beds	0.74	0.55	1.00			
Provider area						
Midwest vs West	0.92	0.67	1.25			
North East vs West	1.36	0.99	1.87			
South vs West	0.94	0.72	1.22			

COPD chronic obstructive pulmonary disease

it has remained constant in the Premier database. In males, the proportion has remained constant in both databases. This proportion of recurrent FHRs is likely between 5 and 6% in females and between 16 and 21% in males in the United States. Unfortunately, our institutional analysis, despite combining data from three high volume institutions, was underpowered and, therefore, we were unable to draw conclusions from this analysis. This highlights the rarity of the procedure, which limits research on this topic.

Our reported proportion of FHRs for recurrence is much higher than the prior reports of recurrence rates ranging from 0 to 6.1% following FHR [2–4, 7, 10–17]. This is especially interesting, as using reoperation for recurrence as a surrogate marker for hernia recurrence has been shown to underestimate the true recurrence rate by over 40% [18]. One reason for the difference in our findings is the use of our large study population compared to numerous single institution studies with smaller numbers of femoral hernia patients. Studies from single institutions vary greatly, as the inter-hospital variation has been shown to be between 3 and 20% [18]. This finding signifies that recurrence following FHR continues to be a clinical concern in the United States.

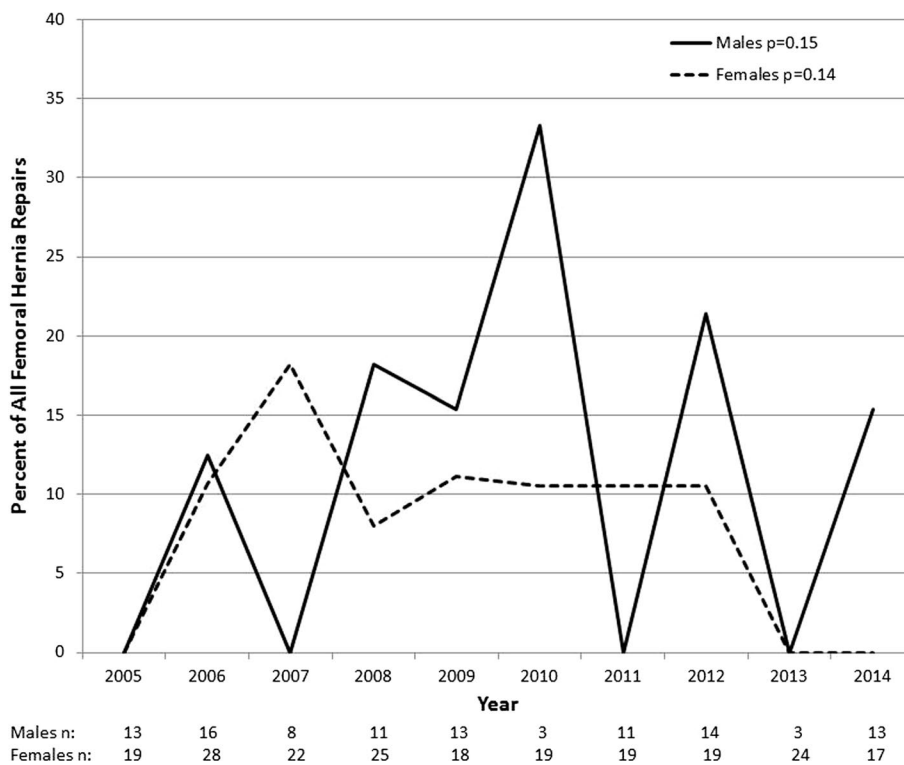**Fig. 3** Proportion of femoral hernia repairs performed for recurrence—institutional database

	Males p=0.15	Females p=0.14

Males n: 13 16 8 11 13 3 11 14 3 13
Females n: 19 28 22 25 18 19 19 19 24 17

Table 5 Univariate and multivariable analysis of Mayo data sources

	Mayo univariate analysis			Mayo multivariable analysis		
	Odds ratio	95% CI		Point estimate	95% CI	
Operation year	0.99	0.87	1.13	0.997	0.87	1.14
2010–2014 vs 2005–2009	0.85	0.39	1.84	0.88	0.40	1.94
Age						
Age ≥ 75 vs 18–64				1.05	0.46	2.40
Age 18–34 vs > 74	2.07	0.41	10.55			
Age 35–44 vs > 74	3.44	0.63	18.98			
Age 45–54 vs > 74	1.40	0.46	4.22			
Age 55–64 vs > 74	0.47	0.10	2.18			
Age 65–74 vs > 74	0.95	0.34	2.66			
Gender female vs male	0.68	0.31	1.49	0.72	0.33	1.61
Emergency yes vs no	0.38	0.15	0.97	0.41	0.12	1.41
Bilateral yes vs no	0.45	0.06	3.48	0.36	0.05	2.80
Diabetes yes vs no	0.99	0.12	7.99	1.45	0.16	13.16
COPD yes vs no	0.60	0.08	4.72	1.13	0.13	10.05
Inpatient vs outpatient	0.50	0.21	1.16	0.81	0.27	2.43

We included both primary recurrent FHRs and those who underwent multiple repairs for recurrences in our evaluation. A previous study at a large volume hernia center estimated the recurrence rate following primary hernia repair to be 6.1%, which increased to an average of 22.2% for multiple recurrences [15]. Furthermore, they showed that 55% of recurrences occurred within 1-year of operation and 67% within 1-years of operation [15]. The majority of previous studies have a follow-up of less than 2-years, likely missing up to one-third of recurrences [3, 12–14, 19]. Taking these factors into account, and combining our female and male

patients into one cohort, our findings are likely similar to prior comparable reports from other countries [15].

In all of our data sources, greater than two-thirds of our patients were female. Females composed the majority of patients in both the primary and recurrent repair cohorts. It is well known that femoral hernias are more common in females [8, 10, 11, 15, 19–22]. Our analysis of the NSQIP database showed a decrease in the proportion of repairs performed for recurrence in females throughout the study period. Possible reasons for this decrease include an increased identification of femoral hernias in females, either from evaluation by laparoscopic surgical techniques, physical exam, or imaging evaluation, resulting in an increased number of primary repairs that occurred throughout the study period, offsetting the ratio of recurrent to primary repairs. Another possible explanation could be a decreased rate of recurrent repairs due to improved laparoscopic techniques, as surgeons have continued to perfect their laparoscopic techniques for FHRs over the study period. Finally, there may be a less complex patient cohort in the NSQIP dataset over time as more regional hospitals joined than larger national academic centers over the study period.

We also found that more patients presented in need of an emergent repair for primary repairs, but had planned procedures for recurrent hernias. This was further shown in our multivariable analysis, where women and those undergoing emergent repair were at decreased risk of having a repair performed for recurrence in both of our national databases. While it is known that patients with femoral hernias are more likely to present in an emergent situation, our study showed that this risk may decrease after a previous repair [6–8, 10, 11, 23]. Additionally, we showed that diabetics have a decreased likelihood of undergoing a repair for recurrence. Diabetes, COPD, obesity, and smoking are all medical comorbidities that can be associated with a decreased life expectancy that could shorten the duration for a recurrence to occur. The other explanation could be that these patients are less likely to have a recurrence surgically repaired due to their medical comorbidities, if symptoms are mild.

By evaluating two large national databases, we were able to estimate the recurrence rate after a FHR in the United States, using the proportion of procedures performed for recurrence as a surrogate for the true rate. The differences between our findings in the NSQIP and Premier data sources likely stem from the variation in the composition of each database. NSQIP is composed of quality-seeking hospitals, which are largely composed of academic medical centers. Premier Incorporated is a purchasing group, with a subset of participating hospitals contributing to their medical database, providing a more heterogeneous composition of hospitals than the NSQIP database. Currently, the United States does not have a national groin hernia database to follow patients longitudinally to determine the true recurrence rate following FHR [9]. We, therefore, evaluated the proportion of FHRs for recurrence in multiple different data sources, as this provides a more representative depiction of the current state of femoral hernia repairs across the United States than just one data source.

In addition to acknowledging that reoperation is an underestimate of the true recurrence rate, our study has other limitations. Using national databases, we cannot follow individual patients over time and a single patient can be captured in the database many times, if he or she undergoes subsequent FHRs for recurrence. Therefore, our reported rates are higher than what they would be for primary recurrent repairs alone. Additionally, it is likely that a subset of patients were in both the NSQIP and our institutional data, and in NSQIP and the Premier databases. Finally, hospitals in NSQIP are focused on quality improvement, while Premier is a purchasing group; therefore, these two groups may not be perfectly representative of the overall state of recurrent hernia repairs across the entire United States [9].

Conclusions

National databases show the proportion of femoral hernia repairs performed for recurrence remained relatively constant in males in the United States between 2005 and 2015. In females, a decrease was seen in one of the national databases. This proportion was between 5 and 6% in females and 16–21% in males in the United States. As the proportion of repairs performed for recurrence underestimates the true recurrence rate, the recurrence rate following femoral hernia repairs in the USA are likely much higher than previously reported and continue to be an important clinical outcome.

Compliance with ethical standards

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