



Original research article

Utilization of MRI technique in the patient population admitted between 2011 and 2015 to the University Clinical Hospital in Olsztyn



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ABSTRACT

Introduction: Magnetic resonance imaging (MRI) is one of the high-tech diagnostic-imaging methods, popular due to non-invasiveness, painlessness and delivery of high-volume information in a short time. **Aim:** The aim of study was to analyze the prevalence of specific diagnoses and demographics of the patient population examined using MRI during 2011–2015 at the University Clinical Hospital in Olsztyn (UCH).

Material and methods: Data from the study population (gender, age and diagnosis) were collected over a 5-year period and SPSS software was used to analyze the frequencies of descriptive variables.

Results and discussion: This report presents data and demographic analyses generated during a 5-year utilization of the Siemens Magnetom Trio. Over this time, there were 12381 patients and 13298 visits, averaging 2660 visits per year. The scans were more commonly performed on female than male patients, 61.3% and 38.7% respectively. Patient age ranged from 2 to 92 years, and the largest group, third part of all visits, consisted of visitors between 51 and 60 years. During these 5 years, MRI diagnoses were applied in 19 out of 26 main letter-coded categories of diseases and health problems as classified by the ICD-10. More than half of all visits concerned the musculoskeletal system and connective tissue; less common, but still frequent were diseases of the nervous system; neoplasms; symptoms, signs and clinical findings not elsewhere classified; injury, poisoning and certain other consequences of external causes.

Conclusions: This study reports on MRI utilization at the UCH, and discusses the use of MRI in the best interest of patient.

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1. Introduction

Magnetic resonance imaging (MRI) is a very useful, high-technology medical technique. The advantages of this technique are non-invasiveness, painlessness, decreased discomfort and risk of complications. Whereas the wealth of information in anatomical and functional aspects has been taken in a relatively short time, MRI offers a wide range of use in pathology indication and definition. Low field MRI techniques can be used for guiding, monitoring and controlling percutaneous procedures and surgeries.¹

One of the main advantages of MRI in comparison to other modern imaging techniques such as computed tomography (CT) and positron emission technology (PET) is that it does not use ionizing radiation. A significant increase in the use of diagnostic

imaging over the last two decades raises questions about possible side effects. CT and PET deliver much higher doses of radiation than conventional radiographs, and increase the risk of radiation-induced cancer. According to Berrington de González et al. who performed estimations on the US population, 2% of annually diagnosed cancers in this country could be related to CT used in the past.² During MRI examination, patients are exposed to a combination of three types of non-ionizing electromagnetic fields. There is no unambiguous evidence of the negative effects of magnetic fields used in medically applied radiation doses on patients' health.³ Moreover, the fetal MRI procedure is safe at less than or equal to 3T during the second and third trimesters.⁴

Though the history of MRI is not very long, it is very dynamic. In the 1970s, advancements in science and medical technology gave the base for MRI, but commercialization was not possible until the 1990s.⁵ The first MRI scanner was built by Raymond Damadian in 1977 and 1978 and the first scan of the human body was performed.⁶

In the early 1980s, the number of MRI machines worldwide was only 12, but nowadays it reaches approximately 36000. It is

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estimated that in order to meet growing diagnostic needs, the number of MRI machines should be 10–15 per 1 000 inhabitants.⁶ The highest number of MRI machines per capita is in Japan – 46.9 per 1 000 of population.⁷ Based on OECD Health Data, in 2009 there were 3.7 MRI units in Poland per 1 000 of population (for OECD30–12.2 per 1 000 of population).⁸

The University Clinical Hospital in Olsztyn (UCH) is a newly established (2009) medical care center and educational institution. It received its first MRI Siemens Magnetom Trio A Tim System in 2010. At that time, there were only three other 3T magnetic resonance units in Poland. According to OECD Health Data, in 2015 for the OECD32 the number of MRI units was 14.1 per 1 000 000 of population, and for Poland the number rose to 6.4 per 1 000 000 of population. A lower number was reported for only four countries: the United Kingdom, Israel, Hungary and Mexico. The number of MRI exams for the OECD²⁸ was 50 per 1000 of population, for Poland 23. A smaller number of examinations was reported in three countries: Germany, Island and Chile. The highest number of exams performed was recorded in Turkey – 119.⁷

The increased use of MRI as a diagnostic procedure and its high costs invite discussion of its appropriate and inappropriate use, and a reduction of its overutilization.^{10,11} According to Oikarinen et al. 11 7% of all MRI examinations in this study were decided on inappropriately. This number was low in comparison with 23.4% of inappropriate applications of MRI reported by others.¹² The problem of unwarranted MRI examinations is already a concern in Polish imaging diagnostics.¹³ The issue of overuse and the appropriateness of the MRI diagnostic has been raised in countries with the highest number of MRI exams per capita, Turkey and the USA.⁷ Some authors are against terms like ‘overuse of high-tech imaging,’ ‘overdiagnosis of patients’ and make a point that patients should not be denied access to better and less harmful examinations because of overall rising costs. A possibility of more effective use, more accurate, less harmful, and more accessible diagnostics should not be artificially restricted. The costs are connected not only with diagnosis, but also with treatment and hospitalization as well. The non-financial cost of patient comfort, side-effects and pain should also not be forgotten.¹⁴

A spectrum of clinical examinations using MRI techniques has changed over time. In the last decade the most popular examination fields are the spine and the brain, what makes up more than 50% of all scans.⁶ Cardiac magnetic resonance is an invaluable tool in differential diagnostics of heart diseases, and in differential diagnostics of coronary artery disorders.^{15,16} MRI is an excellent tool in the diagnostics and monitoring of central nervous system disorders including multiple sclerosis, acute stroke, and brain tumors,^{17–19} and functional magnetic resonance gives the possibility of improving diagnostic and brain tumour resection surgery planning.²⁰

2. Aim

The aim of the study was to analyze the MRI utilization patterns in diagnostics and characterize the demographics of the study population examined during the first 5-years of employing the 3T MRI Siemens scanner at the UCH.

3. Material and methods

Siemens Magnetom Trio A Tim System has been installed in 2010 at the UCH. It is a high technology 3T magnetic resonance unit, used for patient diagnostics and research since 2011. This report presents data on MRI visits, patients, and diagnostics.

For this study, electronic MRI records were collected between 2011 and 2015, during the first 5 years of using the 3T MRI scanner in the MRI Laboratory at the UCH. Patients were stratified into subgroups by age and gender for analyses. All patients’ data were coded by professional hospital staff in accordance with the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10).²¹ No personal identifying information such as patient name and PESEL number were available to investigators. All patients were given unique identification numbers. The study subject had the same identification number in the first one and all following visits. The total number of visits exceeded the number of study subjects, as some patients had more than one MRI scan performed either over each of the study years, or cumulatively over a 5-year period. Two or more visits of the same patient with exactly the same ICD-10 code in the same year were counted only once to avoid over counting during analyses.

All examinations performed between 2011 and 2015 were included in the analyses, and there were no data rejected due to incompleteness of health information or due to the sporadic nature of the disease. Data processing and analyses were performed using IBM SPSS Statistics v.24 software. General demographics and overall diagnostic data concerning examinations (number of visits) were analyzed year-by-year and over a 5-year period. Using SPSS the estimation of the variable (gender, age ranges, general diagnosis type, specific code of diagnosis) frequency were performed. Descriptive statistics was used to characterize patient population and diseases categories. To check for correlations between variables, cross-tabulation was used. The data coding, processing, analyses and evaluations were performed in 2016.

4. Results

During the 5-year period of MRI utilization at the UCH, there were a total number of 12381 patients and 13298 MRI examinations. In the first 3 years, the number of visits were systematically and appreciably rising. In 2013 the number of examinations was the highest in the 5-year period and then slightly declined. [Table 1](#) shows the number of MRI examinations and changes in MRI use over the years 2011–2015.

The age of the analyzed population ranged from 2 to 92 years, the median age of patients was 51 years. [Fig. 1](#) demonstrates age related prevalence of performed MRI diagnostic examinations cumulatively during the whole period. The number of examinations performed on females each year, and during the 5-year period, was on average higher than the number of MRI scans performed on males ([Table 2](#)). The highest number of MRI scans was performed in the age range of 51–60, both for females and males. Patients in the 5th decade of life have higher rates of MRI utilization, compared with younger and older subgroups of the

Table 1
MRI visits by year and annual percentage changes of MRI utilization.

Demographics	2011	2012	2013	2014	2015	Total	Average	Median
Females	877	1440	2159	1939	1736	8151	1630	1736
Males	566	900	1368	1200	1113	5147	1029	1113
Total	1443	2340	3527	3139	2849	13298	2660	2849
Annual percentage changes	100↑	62↑	51↑	11↓	9↓			

Source: MRI Laboratory, University Clinical Hospital in Olsztyn 2011–2015.

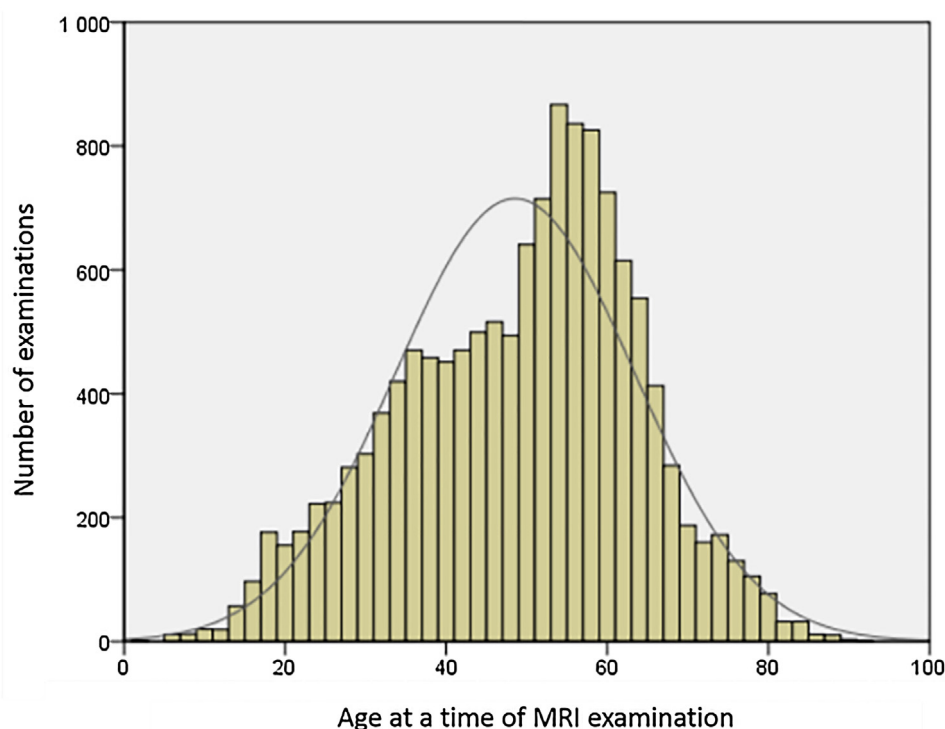


Fig. 1. Age related prevalence of the MRI examinations performed between 2011–2015 cumulatively.

Table 2

MRI visits by year and demographic characteristics.

Age range	Females					Males						
	2011	2012	2013	2014	2015	Total	2011	2012	2013	2014	2015	Total
0–10	3	4	1	5		13	5	5	7	4	10	31
11–20	34	56	74	63	67	294	27	39	53	57	34	210
21–30	87	123	163	161	136	670	84	85	134	114	120	537
31–40	118	202	353	298	270	1241	119	158	221	219	210	927
41–50	186	312	415	410	359	1682	91	178	241	226	202	938
51–60	259	445	637	601	501	2443	137	296	414	374	305	1526
61–70	123	212	360	293	316	1304	68	113	211	164	193	749
71–80	61	81	136	93	82	453	30	20	68	37	36	191
81–90	6	5	20	14	5	50	5	6	19	5	3	38
91–100				1		1						
Total	877	1440	2159	1939	1736	8151	566	900	1368	1200	1113	5147

Source: MRI Laboratory, University Clinical Hospital in Olsztyn 2011–2015.

population. The highest number of examinations (90%) was performed for patients aged 30–70, whereas under the age of 21 and over age of 71 the number was much lower; 4% and less than 6%, respectively. The number and demographic characteristics of the examinations are shown in Table 2. Among the patients

examined by MRI only a few were scanned more than twice in the same year. The frequency of examinations is presented in Table 3.

Out of 26 main letter-coded categories of diseases and health problems according to ICD-10, 19 were diagnosed by MRI. Fig. 2A demonstrates the frequency of code groups among all

Table 3

Number of the patients examined by MRI technique and the frequency of the patients examinations.

Year	2011	2012	2013	2014	2015	Total	[%]	Average	Median
Number of patients	1352	2158	3263	2943	2665	12381		2476	2665
Patients examined once per year	1271	1985	3022	2577	2498	11353	91.7	2271	2498
Patients examined twice per year	72	164	220	358	152	966	7.8	193	164
Patients examined thrice per year	8	9	20	7	13	57	0.5	11	9
Patients examined four times per year	1	0	0	1	2	4	0.0	1	1
Patients examined five times per year	0	0	1	0	0	1	0.0	0	0
Patient examined more than once	81	173	241	366	167	1028	8.3	206	173
Total number of examinations	1443	2340	3527	3139	2849	13298		2660	2849

Source: MRI Laboratory, University Clinical Hospital in Olsztyn 2011–2015.

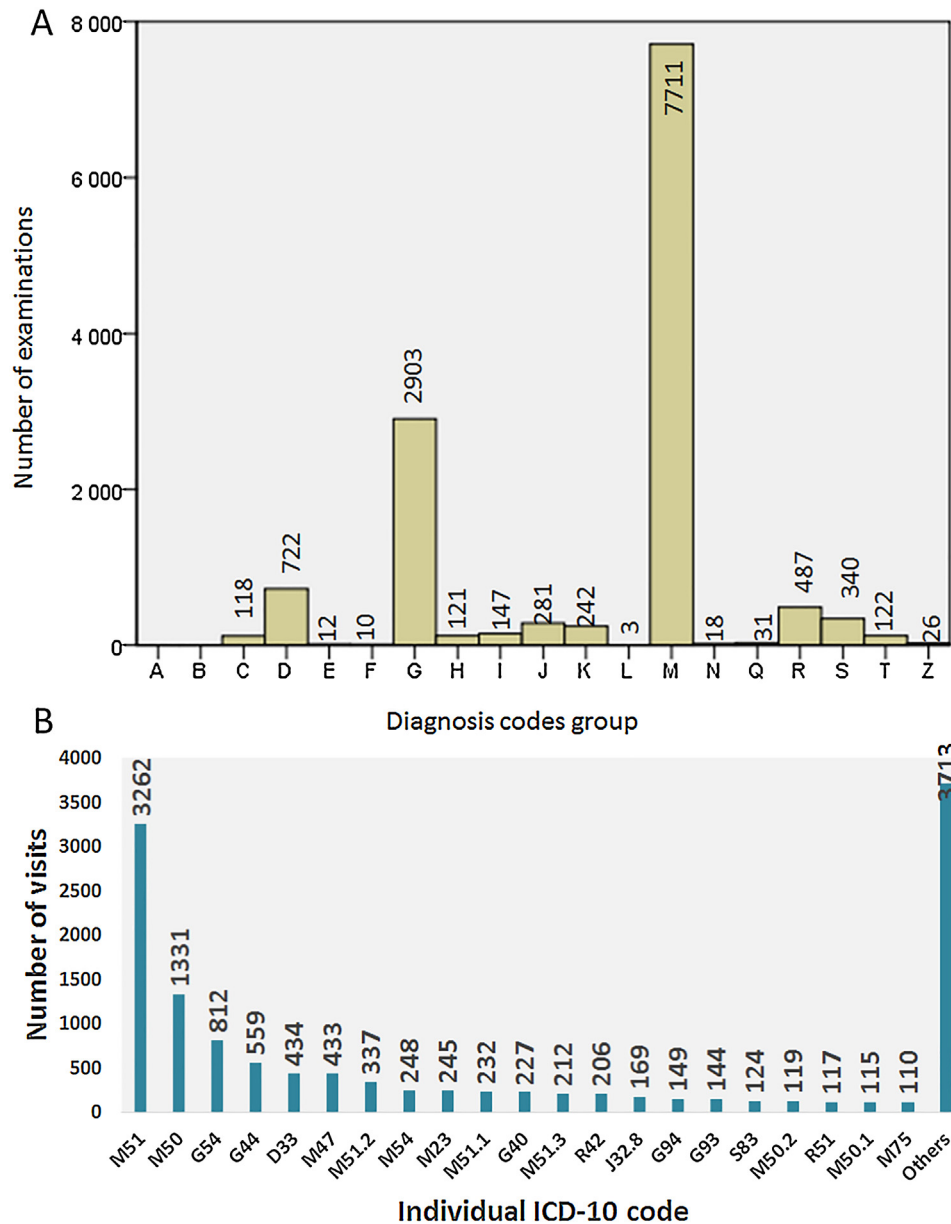


Fig. 2. Cumulative frequency of ICD-10 codes between 2011 and 2015; A – code groups and B – individual codes.

examinations performed during 2011–2015. The MRI was utilized during 13298 visits, of which almost 60% of performed examinations were in M letter-coded category. There were following disease category subgroups: nervous system (G); neoplasms (C and D); symptoms, signs and laboratory findings not elsewhere classified (R); injury, poisoning and certain other consequences of external causes (S). After the M subgroup of diagnosis was excluded, the number of remaining visits and patients decreased to 5587 and 5454 respectively.

During the 5-year period, 632 individual ICD-10 codes of diagnosis were recorded. Almost a half of this number were rare codes, diagnosed only once (in individual examination) in the studied period (Table 4). The group of common and very common diagnoses included 21 individual codes. The most predominant were two diagnosis codes M50 and M51, both referring to diseases of the musculoskeletal system and connective tissue (M), and each of them was noticed in more than 1000 examinations (Fig. 2B).

5. Discussion

In some highly-developed countries, like the USA, the medical market is saturated with MRI machines, therefore the scanners may often be frequently but unnecessarily used. The high-tech diagnostic equipment statistics still show a significant deficiency of MRI scanners in Poland, and the possibility of routine MRI usage in trivial cases appears to be unlikely.⁷ The average number of 1494 scans per 1 MRI machine per 1 year was performed in 2010–2011 in University Hospital, in North Carolina.²² Our reported here analysis shows more intense exploitation at UCH, in years 2012–2015, with an average of 2660 visits over the 5-year study period (Table 1). The 5-year period is quite a short time to properly estimate a trend in MRI utilization, however, the annual changes in performed examinations were noticed (Tables 1 and 2). In the first 3 years, there was a rapid growth of numbers of MRI scans, followed by a decline over the next 2 years. This could be related to the

Table 4
Frequency of individual ICD-10 diagnosis codes reported during 5-year MRI utilization.

Number/range of diagnose noticing	Number of individual ICD-10 codes	Percentage of code number	Category of frequency
1	298	47.2	Very rare
2	84	13.3	
3–10	154	24.4	
11–30	46	7.3	Rare
31–100	29	4.6	Common
101–1000	19	3.0	
More than a thousand	2	0.3	Very common
Total	632	100	

Source: MRI Laboratory, University Clinical Hospital in Olsztyn 2011–2015.

availability of new MRI laboratories in local hospitals and the consequent patient distribution between these MRI service providers.

There could be many factors affecting demographic and health parameters of the studied populations. In the large-population studies, MRI scans of spine and backbone, extremities, central nervous system, and cardiovascular system were the most prevalent.^{23,24} However, about 50% of all emergency cases were referred to MRI for head diagnostics, as reported by Niska et al.²⁵, pointing to the applicability of this method in often life-saving urgent care.

The small number of visits/patients with specific types of disease in populations diagnosed with MRI may not mean that this disease is extremely rare in the general population, instead, due to the personal physicians' choices or availability, patients could be preferably referred to other diagnostic tools such as CT, ultrasound, mammography, or X-ray. For instance, Smith-Bindan et al.²⁶ observed that the use of CT in the abdominal area was significantly higher compared to the use of MRI for the same region, whereas in the last decade, there was a substantial decline in abdominal X-ray-assisted examination. It is possible that increased use of advanced and therefore more expensive diagnostic methods rising health care costs, may not always be justified. Although it is not always easy to identify the most beneficial imaging test,²⁶ however, selection of diagnostic tools best for the specific cases is still dependent on the given equipment availability and physician's experience and choice.

Our study allowed us to identify the most commonly diseases and disorders diagnosed with MRI at UCH (Fig. 2A and B, Table 4). Musculoskeletal system and connective tissue disorders, diseases of the nervous system, neoplasms and consequences of external causes were the most common groups of diagnoses, with injuries, intervertebral disc disorders most frequent. Spinal nerve root and plexus disorders, headache syndromes, benign neoplasms of brain and other parts of the central nervous system were also among very common specific diagnoses.

Similarly to the results of Smith-Bindan et al.²⁶, we have also observed differences in the number of MRI examinations performed in different age ranges (Fig. 1). However, the patterns of age-related MRI examination frequencies were slightly different. In Smith-Bindan study, the entire 45–84 age range showed high and quite stable rates, whereas in our analysis, high MRI examination rates started earlier, in a 10-year younger group of patients between 31 and 70 years of age, with a distinctly highest MRI frequency in the 51–60 age range.

Freid and Bernstein reported the chronic illnesses being more common in adults of 55–64 years of age, than in younger study subjects,²⁷ and this finding could help to explain our results. The number of examinations performed in patients 70 years and older was in our study relatively low and similar to that performed in patients 20 year old or younger, whereas MRI enrollees 70 years and

older were a significant group in studies of Smith-Bindman et al.²⁴ and Freid and Bernstein²⁷.

The frequency of repeated imaging was lower than reported in the literature.²⁶ Only under 10% of patients were examined more than once, and only 5 patients were scanned 4 or more times over the 5-year period (Table 3).

6. Conclusions

Pathologies diagnosed with MRI include mostly the diseases of the musculoskeletal system and connective tissue (M category), diseases of the nervous system (G category), and neoplasms (C and D category).

Patients most frequently examined with MRI were within the age group 51–60 years, both in the female and male sub-groups.

Data presented can be used to review decisions of using MRI or other imaging techniques, to assure the best possible matching of diagnostic methods to the patient's needs.

Conflict of interest

The authors declare no conflict of interest.

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