

The Significance and Considerations of Claustrophobic Reactions in Magnetic Resonance Imaging

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ABSTRACT

Magnetic Resonance Imaging (MRI) scans have taken over the imaging world, altering how patient care, diagnoses, and treatments are developed and carried out by allowing an internal look at the human body with noninvasive equipment and no radiation exposure. MRI is an essential study for most patients and to their treatment plans by detecting early onset pathologies and diagnoses and can be credited with revolutionizing the healthcare industry. However, MRI scanners and equipment can cause difficulties for patients during the procedure, producing anxiety reactions of claustrophobia, often resulting in premature terminations of MRI examinations. As this is a known problem since the initiation of MRI use, considerations for claustrophobia have been developed and utilized. Specific considerations for claustrophobia were directly correlated with more positive reactions during an MRI examination. This research provides a literature review that outlines the need for MRI scanning, the prevalence and causes of claustrophobic reactions, and the considerations that can be taken by technologist, healthcare provider, or patient themselves in preparation for an MRI examination when claustrophobia is present.

Keywords: Claustrophobia; Magnetic Resonance Imaging; Wide-Bore; Open MRI; Termination; Virtual Reality Tool Simulator; Anxiety; Claustrophobic Reactions; Sedation Medications

Introduction

With advancements in healthcare ever growing, imaging sciences and studies moves upward along with it. [1] Magnetic Resonance Imaging (MRI) scans have taken over the imaging world, altering how patient care, diagnoses, treatments, and therapies are planned, developed, and carried out. [1] As MRI scans are a part of advanced imaging methodologies, it takes a noninvasive approach to seeing inside the body, how it functions and dysfunctions, all the way through from bone, to soft tissue, to muscle, to fat, to water, and all. [1] By allowing an inside look at the body that is noninvasive, physicians plan and carry out therapies, treatments, and care based around the knowledge from these scans. [1] It is an imperative and essential study for most patients who have the orders for the MRI examinations. [1] Without the MRI examinations, one may not receive the care needed for their diagnoses and pathologies, but also may not even be able to be diagnosed at all. [1] According to the article "The Value of MRI in Medicine: More Than Just Another Test?", it could be said that MRI, along

with CT, revolutionized the healthcare industry so much that most physicians today could not practice without the use [1].

Magnetic resonance imaging exams can detect early onset pathologies and diagnoses, while also reducing the radiation exposure presented to the patient in other imaging modalities. [2] This is a huge reason why physicians rely heavily on the use of MRI examinations, hoping that early detection rates and more involved images will help the care given to the patients. [2] However, MRI scanners and equipment can cause difficulties for patients when experiencing the procedure. [2] The closeness of the scanner, the use of overbearing radiofrequency coils, the length of procedure, and the acoustic noises administered during the MRI scans are just some of the reasons why patients may experience claustrophobic or anxiety induced reactions during an MRI procedure. [2] These reactions hinder the amount of successful completions for many MRI exams, often causing premature terminations of MRI procedures for patients. [2] These premature terminations could delay patient care, cause financial detriments to

the hospital, leave lasting impressions with patients, and create loss of time for technologists. [2] By examining the statistics for premature termination of MRI exams or cancellation of appointments due to claustrophobia, there may be a way to combat these statistics to better help future patients with claustrophobia complete the exam comfortably [3].

Literature Review

Why MRI?

To understand the need for new considerations to equipment, scan time, sedation techniques, and others to allow patients a better experience during MRI procedures as well as ensuring completion of procedures, it must first be researched why MRI is such an important modality. As far as specifics among the modality of MRI itself, compared to other imaging or invasive choices, breast, neurologic, pulmonary, musculoskeletal, prostate and abdominal imaging have all been heavily effected and advanced by MRI scans. [1] Inside the article, "The Value of MRI in Medicine: More Than Just Another Test?", it is stated that Breast MRI imaging is the most effective modality for screening and diagnosis of breast cancer over other modalities, by far – and according to a study outlined in this article, can take as less as 3 minutes in MRI imaging to diagnose accurately. [1] Rapid stroke detection, shunt placement, and dementia care are all three favored for MRI imaging over other modalities, which accounts for many brain scans done. [1] Without the effects and use of ionizing radiation, exams such as PE studies done with angiography methods in MRI maintain a safer, and just as good, alternative as CT angiography. [1] Continually, with the ability to postprocess MRI sequences in 3D software and to manipulate the presentations in all 3 planes allows musculoskeletal imaging to be high resolute, and as detailed as possible – showing not only fractures and bone findings, but muscle, tendon, ligament, and others [1].

The prostate cancer diagnosis rate continues to rise due to the use of MRI for detection, without meaning an invasive biopsied procedure that are waited on and only used when the nature of the patient calls for it. [1] By allowing a look inside the body and allowing potential detection without invading has provided an alternative screening that is less invasive, costly, and more comfortable for the patient. [1] Cirrhosis, hepatocellular carcinoma (HCC), and nonalcoholic fatty liver disease (NAFLD) are all screened for and detected using MRI as the choice modality due to the sensitivity, detail, and resolution of the scans. [1] With just as high if not higher detection rates, better resolution and detail, less invasive and costly in some instances, and always safer without the use of ionizing radiation, the modality of MRI as a whole is very valuable in terms of patient care. [1] Adding in the ability of physicians to utilize these scans in the diagnosis, treatment and therapy plannings, and others adds value. [1] MRI will stay advancing, decreasing scan times and noise, replacing equipment for comfortability and support of the patient, and attempting to be

as least anxiety inducing as possible – which will continue to keep MRI not only relevant, but essential in healthcare. [1] By examining the statistics for premature termination of MRI exams or cancellation of appointments due to claustrophobia, there may be a way to combat these statistics to better help future patients with claustrophobia complete the exam comfortably [3].

Prevalence of Claustrophobic Response in MRI

Claustrophobia causes patients to feel anxious about the MRI scan or equipment used during, and can cause cancellation of exams or increased motion artifacts. [4] This in turn could cause a degradation of image quality or could keep patients from receiving the MRI scans, which could be extremely helpful to a diagnosis or therapy plan. [4] According to the article "Virtual Reality Tool Simulates MRI Experience", when surveying patients about an MRI experience, 65% of patients felt distress with the inability to move, 61% felt distress with the length of the study, 48% felt distress with the size of the bore, and 50% felt distress upon being moved into the bore. [4] With these rates of anxiety, there is a high volume of termination of exams prior to completion and motion-related artifacts in a scan when being done. [4] In other studies, claustrophobic reactions have been reported to have been triggered during an MRI scan at an incidence rate of 37%, with an up to 14.5% incidence rate of premature termination or cancellation of procedure. [3] It was found in this study that the claustrophobic response was more prominent in females over males, and in brain and neck imaging over others. [3] Up to 14.3% of all MRI procedures are estimated to be effected by claustrophobia, according to Dewey, Enders, Iwan, Napp, and Yang [5].

Additionally, in the article "Claustrophobia during magnetic resonance imaging: Cohort study in over 55,000 patients", it was explained that up to 15% of patient undergoing an MRI examination develop claustrophobic reactions that keep the patient from having the procedure or cause a need for sedation intervention to complete the examination. [6] The premature termination of MRI scans due to claustrophobic reaction, reported by Simon in an article regarding hypnosis treatment for MRI, has been recorded up to 1-20%. [7] In a study by Almutlaq in 2018, entitled "Discussion of the Causes, Effect, and Potential Methods of Alleviating Patient Anxiety When Undergoing Magnetic Resonance Imaging (MRI)", it was outlined that up to 37% of patients for MRI procedures have claustrophobia, and up to 15% of the patients for MRI express claustrophobic concerns. [8] Thinking in terms of real patients yearly, this accumulates to thousands of patients experiencing these symptoms. [8] At up to 39% of patients prematurely terminating an MRI examination, doctors are unable to produce sufficient readings for these scans as well. Research also shows patients, the majority of the time, no-show an average of 4 appointment due to fear of the scan itself [8].

Not only are these issues bad for patients and the diagnoses, but also for the hospital due to financial losses. [8] At a large scale, up

to 310 million dollars are lost in the US yearly as a result of 700,000 incomplete MRI examinations. [8] The last of the articles in the research disclosed differing amounts as well. According to "Medication Safety Events Related to Diagnostic Imaging", up to 15% of patient either cannot complete the MRI examination due to a claustrophobic reaction, or needing pharmaceutical sedation intervention. [9] In a study researching prevalence of claustrophobic reactions from MRI for patients post-CABG (coronary artery bypass graft) surgery, 4% - 30% of patients receiving an MRI would result in anxiety responses, leaving up to 5% of patients to prematurely terminate the MRI exam. [10] In the study's own research of 237 patients post-CABG, 14% experienced such dominating claustrophobic responses that the MRI was prematurely terminated [10].

Causes and Considerations for Claustrophobic Reactions in MRI

As stated previously, when surveying patients about an MRI experience, 65% of patients felt distress with the inability to move, 61% felt distress with the length of the study, 48% felt distress with the size of the bore, and 50% felt distress upon being moved into the bore. [4] Having anxiety-inducing claustrophobia can increase the risk for panic attacks, high stress levels, and premature terminations or cancellations of an MRI exam appointments. [3] By examining the statistics for premature termination of MRI exams or cancellation of appointments due to claustrophobia, there may be a way to combat these statistics to better help future patients with claustrophobia complete the exam comfortably. [2] Widely used to combat claustrophobic responses in MRI procedures is the use of oral or anaesthesia sedation techniques. [2] Techniques of low-dose oral sedatives have enhanced odds of successful completion in patients that are listed in the severe claustrophobic category. [2] These pharmaceutical interventions could definitely help a patient complete an MRI procedure, especially when utilized to the fullest extent of anaesthesia sedation, which includes patients undergoing surgical anaesthesia, with strong monitoring, many medicines, and mechanical ventilation. However, this is not always the best choice, and definitely cannot be the choice for every patient experiencing claustrophobia for MRI. There was a note that 12% of sedated patients in a study had increased motion on the MRI images [2].

When administering any type of sedation intervention for an MRI procedure, the cost and risk of the magnetic resonance scan increases dramatically. [7] Often times, even after sedation intervention, patients may still be unable to complete the procedure. [7] 7% of the safety events related to the use of medications happened while in the imaging department or receiving an imaging procedure. [9] Important considerations with regards to sedation intervention for MRI procedures could be those who have renal, hepatic, and lung disease, sleep apnea, lower BMI values, or scale ratings, aspiration, and oversedation. [9] This is why there is a need to look farther into changing MRI machines and examinations to better engage with claustrophobic

patients. The first source dives into an idea of a virtual reality tool used to allow patients to use a smartphone app, and experience an MRI environment prior to the MRI procedure itself. [4] By being able to repeat an experience that makes a patient uncomfortable, with accurate surroundings and sounds, a patient may become desensitized to some anxiety triggers felt during an MRI scan. [4] For this tool to work and effectively prepare patients for the procedure experience, the VR product would need to be an accurate representation of the MRI environment, room, and equipment. The app simulated the experience with 3D cameras, creating a space much like a 3D game. [4] This would allow patients to view what the room would look like prior to getting onto the table, laying on the table, and then once inside the magnet bore [4].

Once the sight of the MRI room was represented, spatial audio was added in of recordings of an actual MRI scanner, to ensure the patient would be prepared for the noises of the machine as well. [4] This could ensure a patient has as much information prior to the MRI procedure as possible. Another study focused solely on the exterior look and build of the MRI machine itself, and how that could influence claustrophobic responses from patients. [5] It was established that many times a claustrophobic reaction to an MRI scanner happened prior to being on the table and during the exam, rather happening before the patient was even positioned just based on the patient looking at the scanner. [5] With this information, research could be done to improve the "look" of the MRI scanners to better help future patients establish comfort prior to being scanned. [5] The surveyed patients were shown four drawings of different MRI magnet constructions and the diagnostic performance statistics based on each specific design. [5] The purpose of this study was to assess what features patients who are high risk for experiencing claustrophobia during an MRI prefer regarding the development of an MRI scanner. [5] Upon assuming equal diagnostic quality, more than half (51.9%) of patients preferred the upright open scanner design for future examinations, and the least being 3.8% preferring a short-bore scanner experience [5].

Once being educated on scanner performance, the majority of patients preferred an open panoramic scanner at 51.9%, and next the short-bore scanner at 30.5%. [5] This would elude that not only does comfort and claustrophobia play a part in MRI experience, but so does the influence of diagnostic quality. [5] Aside from the actual construction of the MRI equipment and bore, 32% of patients suggested a reduction of noise, 27.5% suggested more over-head space, and 21% suggested more overall space as improvements to future experiences and preferences. [5] Using the data from this research, one could focus on a less noisy, open bore MRI machine to provide the best experience for patients with claustrophobia. [5] In a study of over 55,000 patient exams, using newer scanners that employ the techniques that battle claustrophobia (noise reduction and shorter wide-bore magnets) and scanners that are older without the new techniques, females, going head-first into the scanner, with afternoon

appointments were most likely to have anxiety responses to the MRI examination. [6] However, overall the claustrophobic reactions felt by patients were decreased by a factor of 3 when utilizing the MRI scanner equipment that employed noise reduction techniques and shorter, wider bores. [6] Considerations are normally termed “patient-friendly properties” due to the implementation being for the comfort of the patient, aimed to help better assist a patient through the procedure [10].

Adding tools, such as devices to distract the patient or for the patient to interact with, could help reduce the anxiety or comfortability felt during an MRI procedure, such as headphones with music or goggles with video, and could be specifically helpful in a pediatric hospital setting. [10] Adding padding or cushions to ensure comfort can increase patient cooperation, decrease patient motion, and relieve pressure felt from certain positioning, and has been linked to decreasing repeat sequences by 50%. [10] Utilizing technologists who are properly trained on the equipment and how to use the optimized imaging protocols can decrease scan time and repeat sequences as well as make the patient more comfortable by having confident technologists and updated scan times. [10] Hypnotherapy was also an intervention that was used to alleviate some anxiety responses from MRI patients. [7] The hypnotherapist was able to communicate with the patient via headset devices that helped block acoustic noise of scanner and increase volume of hypnotherapists. [7] The patient was surveyed and relied heavily on the hypnotherapist’s presence during the procedure, and was happy with the results of the scan which allowed the doctors to resume and continue care for the patient. [7] Limiting acoustic noise and preparing patients more effectively are also important ways to decrease patient anxiety about an MRI procedure [8].

New MRI scanner equipment can reduce noise up to 97% and have wider bores for more comfortability for the patient. [8] It could be possible to enhance an MRI experience so that every patient has a chance to receive what could be named one of the best and most effective imaging tools of the world [8].

Why is Battling Claustrophobia in MRI Important?

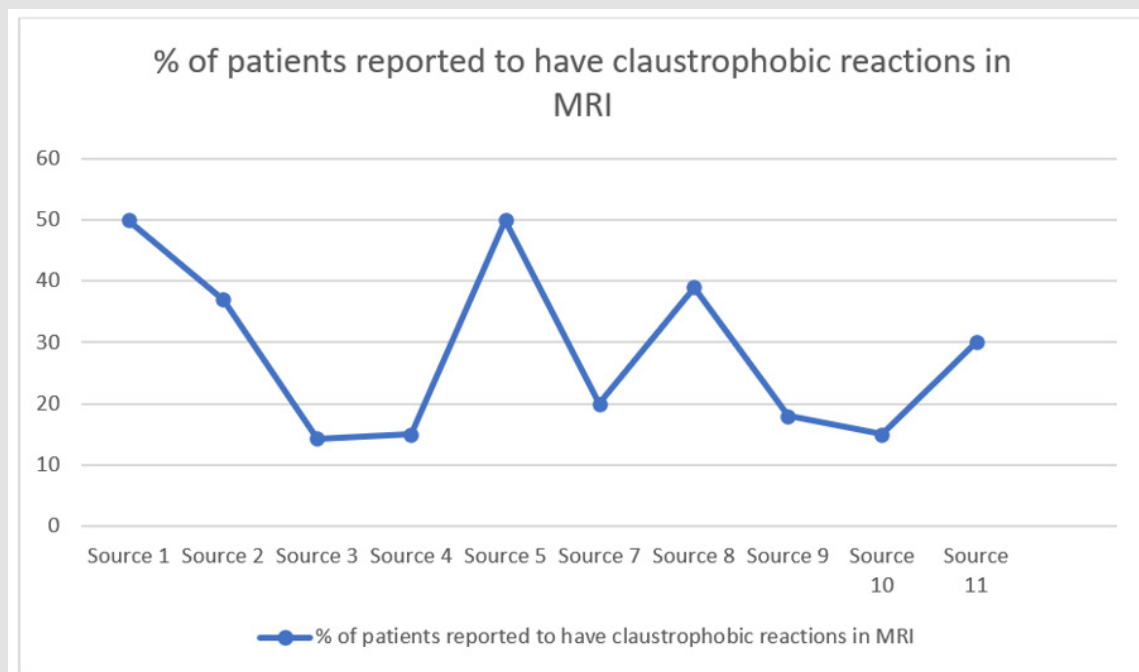
Looking back at the previous points in Why MRI?, it is an efficient tool that changes the course of millions of diagnoses and treatment plans for patients around the world. However, due to the nature of the MRI equipment and scanner sequences, many patients find it hard to finish or undergo an examination due to anxiety-induced reactions called claustrophobia. [8] Claustrophobia can have a direct result on

patient diagnostic image quality. [8] Remembering that MRI scanners do not use radiation, these scans can last for longer periods of time, resulting in longer times patients will need to hold a position, adding claustrophobia to that mix will result in motion artifacts. [8] A study also revealed that claustrophobia can result in effects of a patient’s body muscles, which could increase patient motion. [8] Degradation of diagnostic quality due to motion can seriously effect a radiologist’s ability to interpret a scan, and giving an accurate and effective diagnosis. [8] Reducing anxiety responses felt by patients is of the upmost important to healthcare facilities, and patients – to improve diagnoses and fiscal loss.8 Sedation intervention is highly employed to assist a patient in finishing or achieving an MRI procedure, thus increasing examination risk and cost [8].

Due to the fear of enclosed spaces, claustrophobia can cause reactions that translate into physical responses from the body. [9] These responses that are triggered due to the enclosed spaces of the MRI machine can result commonly in increased blood pressure, increased heart rate, perspiration, increased respirations, and many more physical responses. [11] Tagging along with these anxiety-induced responses, come other real physical symptoms that can effect patients long after an MRI examination is completed.6 The effects of strong anxiety on the body can include, but are not limited to, hypertension, nausea, fears of actual harm, light-headedness, fainting, and tachycardia [12].

Methods

The methods when commencing this literature review process relied heavily on finding articles and studies that corresponded to the needs of the research, needing to know statistics of prevalence of claustrophobic reactions in MRI, as well as how the claustrophobia can be combated and why this was all important. There were limitations to the literature review process, in which articles would outline specific statistics of claustrophobia itself that differed from each other (see Appendix Figure 1). Most studies in the literature review had the same methods, generally. Patients were surveyed and observed regarding the MRI examination prior to, during, and after the process. [1-9,11] However, each of these studies required different methodologies to conduct the research. While source 1 studied a VR tool, that was a smartphone app that patients could access prior to the MRI, and was surveyed after using the app about the ability of the VR tool to help provide comfort to the patient for the MRI.1 Source 4 researched 55,000 patients on 2 different MRI scanner setting and environments. [6] Source 6 had methods of patient questionnaires prior to exam, as well as monitoring before, after, and during examination [12].



Appendix Figure 1.

Statistical Analysis

The statistical analysis done in Appendix Figure 1 outlined the differing levels of prevalence of claustrophobic reactions in MRI to each source researched. When researching this, there were many studies on how often a claustrophobic response occurred, and what initiated the claustrophobic reaction to the MRI examination. It is important to note, however, that the statistics regarding the prevalence of claustrophobic reactions during MRI examinations were scattered throughout the sources (see Appendix Figure 1). Appendix Figure 1 outlines the prevalence of claustrophobic reactions to MRI procedures, according to each source, in a linear view.

Results

The results of this literature review outlined many different aspects of the significance of claustrophobic reactions in MRI. The prevalence was outlined as differing in each source, however, was apparent within each study, showing imperative need for considerations regarding decreased claustrophobic response to MRI procedures. Most of these responses outlined patient comfort measures, changes in machinery of the MRI equipment and coils, auditory scanning

changes, and decreasing the length of the MRI procedure itself. [4-6,11] It was seen in three different studies that female patients, in afternoon appointments, with brain and neck imaging had increased prevalence of claustrophobic reactions. [3,6,12] Upon reviewing a hospital's electronic radiology information system, it was found that a total of almost 2% of patients suffered from known claustrophobia, 1.2% of patients prematurely terminated the MRI scan due to claustrophobia, and 1% had newly found claustrophobia. [3] These statistics must also be discussed simultaneously with the fact that there are more women diagnosed with anxiety disorders than men in society today. [3] The level of highest incidence in which a patient prematurely terminated an exam was during brain or neck imaging, likely due to the coils used during these specific images. [2,3,6,12] The coil required for brain or neck imaging locks onto a patient's table in close proximity to the face and could cause a trigger for claustrophobic reaction [3].

It is also important to note that a prone position during imaging caused less premature termination than supine positioning during imaging. [3,4,6] There was no correlation found with age of patients related to the premature termination of MRI studies, other than most of the patients were from ages 20 to 80 years old [3].

Discussion

There were limitations to the literature review itself, along with each study. Most studies were limited to the MRI equipment at the site of the research, new equipment have noise reduction up to 97% and have wider bores can be found however, not everywhere has access to that. [8] Study 1, researching a VR tool to help enhance patient experience, did not take into account the amount of time a patient may lay for a procedure [4]. This also could change how well a patient is prepared to lay in general, but also excluded the physical responses of laying so long and in a anxiety-inducing environment. [4] Source 2 was limited to a 60 cm bore, and no open bore magnet, which could've definitely changed the results. [3] All research could be limited due to the staff and overall environment and patient care skills of each hospital worker. This has been seen to positively impact the claustrophobic responses if technologists are more empathetic and confident about the procedure. [6,7] By examining the statistics for premature termination of MRI exams or cancellation of appointments due to claustrophobia, there may be a way to combat these statistics to better help future patients with claustrophobia complete the exam comfortably. [3] By educating patients prior to the procedure, with information, VR tools, or hypnosis, about the examination and how much better the quality of this scanner is compared to open-bore scanners may increase the likelihood of patients preferring, or at least being comfortable with, the short-bore scanners [4,5,7].

By understanding patient experience and preferences, the design of future magnets could factor in, not only diagnostic quality, but also patient comfort for main issue of dealing with MRI's, claustrophobia [3].

Conclusion

MRI examinations are one of the most important aspects of a patient's diagnoses, treatment, and care. With the noninvasive imaging, the most detailed images of the body can be obtained. [1] MRI scanners and equipment are known to cause great challenges for patients to face when experiencing this procedure. [2] The MRI scanner look and build, the noise and length of procedure [2,4,5,6,11,12] the technologist [2,4,8,9] and predetermined anxiety responses can have a great impact on why a patient may experience claustrophobic or anxiety induced reactions during an MRI procedure. [7-12] Since claustrophobic reactions are such a common side effect of MRI procedures, many techniques have been employed to attempt to suppress these reactions. [2] By understanding the prevalence of claustrophobic

reactions, and in what ways the reactions can be decreased or diminished can have a huge impact on patient care around the world forever. The advancements of imaging in general have altered patient care throughout the world, however MRI has made leaps and bounds to increase chances of treatment, care, and life – therefore, by understanding how to ensure patients receive and handle this procedure is imperative, essential, and of utmost importance for everyone [1].

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