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Caloric testing interpretation

Ear and hearing, 30(3), 313–319.Caloric testing is an otoneurologic evaluation of the status of the vestibular-ocular reflex; it allows an evaluation of each labyrinth separately. Observations on the directional preponderance ("Nystagmusbereitschaft") of caloric nystagmus resulting from cerebral lesions. You know a lot of Ls. Let's try O. Table of contents What is the caloric test? So you did a wonderful job. When you do that, remember that consecutive nystagmus beats can't be more than a few degrees apart. Looks like it's just starting. Once you determine that the patient is concentrating and looking at the target, this type of abnormality is failure of fixation suppression. I might have to keep reminding you of that because sometimes it's hard to remember to keep your eyes open in the dark. The 1998 study shows that if you start with cool irrigations, the difference is reduced. This suggests the caloric response recorded in Figure 11 is exhibiting hyperactive characteristics. That indicates a unilateral weakness in the right ear. Now, let’s cover some practical considerations when performing caloric irrigations. To save some time, you can wait for the previous caloric nystagmus to subside. This is because – as we have discussed – the whole basis of the caloric test is the heat transfer from the external auditory canal, through the middle ear to the labyrinth. Remember to keep your eyes open. If you do, it will show something that's abnormal. Reassure your patient by explaining that any dizziness experienced is a normal reaction and that the test will not provoke an episode of their own dizziness. About 15 seconds more, down to the last five seconds. This will ensure that the effect of the previous irrigation has subsided before starting the next irrigation. You can see that she's angled at 30 degrees. So your task is going to be that you're going to name people's names that start with a certain letter of the alphabet. Here, the total response is 66 degrees per second and the unilateral weakness is 64% (Figure 6). Shortly after we stop the test, that'll go away. But the downside with air is that it requires more technical skill to administer when compared to water. And now just a few more seconds, five more seconds. Okay, and now the fixation light went off. You can see that the responses from the right ear are much lower than the responses from the left ear. Manual of Electronystagmography. Open-loop water This irrigator is called open loop because water goes into the ear canal, and you're supposed to catch it with the basin when it comes back (an open loop). So this is just a nice example of a patient with a right unilateral caloric weakness. The British Society of Audiology recommends a minimum interval of seven minutes between the start of consecutive irrigations. You're gonna feel a little bit of that motion again. Now it's a little warm. She got a value of 9% for unilateral weakness, so she's got a green checkmark, because that's well below the 25% cut off. Then the fast phases of nystagmus will bring the eyes back toward the irrigated ear. When measured in the caloric position, you can use the spontaneous nystagmus velocity and direction to correct the measured caloric responses to verify whether a true unilateral weakness is present. But once you get past like 22 or 24, you can really rely on the results and she has 31. If you’re using an air irrigator, you might be interested to know that in the USA, ANSI disapproves the use of air as a mode of irrigation. The caloric test is primarily considered as a test of the lateral semicircular canals and the superior part of the vestibular nerve. Okay, so let's give it some time to relax. For example, if somebody has bilateral otosclerosis, the heat doesn't reach the labyrinth. Total cool peak response (left cool plus right cool) is more than 99 degrees per second Total warm peak response (left warm plus right warm) is more than 146 degrees per second Total peak response (total cool plus total warm) is more than 221 degrees per second In Figure 11, the total responses from both ears are high at 263 degrees per second, with the total warm being 152 degrees per second, and the total cool being 111 degrees per second. You’ll also miss the opportunity to identify some of the artifacts. There we go, there's our light. Don't worry about the motion, it's going to go away. Here we go. The water irrigator by Interacoustics is the Aqua Stim (Figure 2) and has the following temperature range: 30 to 44 degrees Celsius. Keep your eyes nice and still. [3] Jacobson, G., Newman, C., Peterson, E., Jacobson, G., Newman, C., & Kartush, J. The design of the irrigator tip may affect the temperatures in the ear. Once the irrigation has finished, you should wait for 5 minutes before starting the next irrigation to ensure the nystagmus has completely stopped. Cool irrigation in left ear Okay, so now we're gonna start the cool irrigations. I only have a few more seconds left and then this irrigation is going to be done in five seconds. If you determine that the hyperactivity is real, and you have ruled out any historical middle ear or mastoid surgery that might expose the labyrinth, then it denotes a central lesion. That was fantastic. So you'll do that. Figure 4: Physiology of warm irrigation. This means if one person has a peak response of 20 degrees per second and another person has a peak response of 10 degrees per second, you can't say that one person's labyrinth is more sensitive than the other because it might be that the heat transfer is not as effective in one person compared to the other. Irrigation You perform the first irrigation with the VNG goggle on the patient with the cover on (vision denied). We can use the hyperactive response criteria published by McCaslin in 2019 [4]. It has the same significance as smooth pursuit abnormalities. What will the patient feel? This is understandable as there is some cerebellum involvement in these patients, so you would expect them to have strong responses to caloric irrigations. In Figure 9, you can see the effect of the 9 degrees per second of left-beating, spontaneous nystagmus the most in the left cool caloric irrigation, which is corrected in the calculation for caloric asymmetry. Warm irrigation in right ear Here we go. If somebody calls and asks if you can test a two-year-old child, the answer is most likely no. And so we want to see what was the peak response for each of the four different irrigations and then we compare them together. So, if you're going to do all four irrigations, it might be best to start with cool. But they're far too embedded in the temporal bone, so the heat transfer is diminished. In cases of suspected bilateral vestibular weakness, you always must do a secondary test. Luna, Lena, Lena. Directional preponderance can be caused by two factors. It's a central lesion that could be in different parts of the central nervous system: Pons Cerebellum Parietal-occipital cortex It's most common in patients with midline cerebellar abnormalities. Okay, you're good. Figure 9: Abnormal amount of spontaneous nystagmus. Vertical nystagmus during caloric testing Vertical nystagmus is quite common, both in normal individuals and patients with different abnormalities. This will stop the endolymph flow and the patient might recover quicker. You must make sure that the nystagmus beats are cleaned up and they actually represent the slow phase velocities. Bilateral vestibular hypofunction Finally, what makes it attractive for unilateral vestibular hypofunction, where we compare the right and left ears, is a limitation when it comes to abnormalities that affect both vestibular systems. It doesn't have any value for localization. And so we're going to be testing each of her ears individually. So we are ready to go. If either the rotational chair or video head impulse test confirm the bilateral weakness as a bilateral vestibular loss, then you can conclude that the patient has a hyporesponsiveness / hypofunction in the semicircular canals of both peripheral vestibular systems. It would be prudent not to interpret it. This recommendation doesn't differentiate between a person who has a very strong response and somebody who has a weak response. But if you ever think that you're going to stop after two irrigations, then definitely start with warm. However, closed-loop water systems are no longer manufactured. Okay, okay. Order of irrigations Both ANSI and BSA recommend that you start with the warm temperature. in 1998 [6] showed that if you start with warm, which is an excitatory response, the very first irrigation is usually stronger than the rest. That's correct. I'm going to blow some air into my patient's ears. There are other things we need to consider with air irrigators. S. It’s reported in the literature that the velocity of the slow phase component of the nystagmus taken at the peak of the caloric response is the useful variable to quantify the caloric reaction [3]. But it's best if you do this for all four irrigations. in 2009 [7] has laid out the parameters that must be satisfied for this type of test: No oculomotor abnormalities No gaze-evoked or spontaneous nystagmus The difference between peak responses should be less than 10% If all these three conditions are met, then it's very likely that your calorics are normal and you can stop after two irrigations. One irrigation is a lot different than the other three Another type of artifact is when one irrigation produces results that are very different than the others. These days, video head impulse testing (vHIT) is much less costly and occupies a much smaller area, so you might try a vHIT goggle. Because the fixation reduces that response a little bit. As it’s one of the few vestibular tests that induces a conflict between the output (efferent) signals from the peripheral vestibular system, it will make the patient experience a sensation of movement, often described as dizziness, and is not well tolerated by some. At least two, one for each direction of nystagmus. Electronystagmography and Videonystagmography (ENG/VNG). Figure 5: Physiology of cool irrigation. Summary Even though the caloric test doesn't identify a specific etiology, it's proven to be the most useful test for detecting unilateral vestibular lesions. So this time we're going to do the left ear with the warm irrigation. It has reached its proper temperature of 48 degrees. How do you reduce the risk of the patient feeling sick? St. Louis, MI: CV Mosby. L. From that point on, wait a fixed amount of time of 3-5 minutes. Advantages and limitations of caloric testing As we have covered caloric testing equipment and the caloric test procedure, let’s cover the advantages and limitations of caloric testing. That will place the lateral canals in the horizontal plane. Once with a medium (air or water) which is of a slightly higher temperature than the normal body temperature and once with a medium that's slightly cooler than the normal body temperature. These papers discussed the basics of caloric testing, the types of stimulation, the interpretation of results, variables, artifacts, and the monothermal and ice water caloric test. Okay, I'm going to take the irrigator out. But she has 70. If you get to a point where you feel like the patient might get sick, interrupt the irrigation and make a note of the time. Are monothermal irrigations enough? For example, if you have a vHIT which is normal, then two irrigations are probably adequate if they also show a minimal amount of asymmetry. The ANSI recommendation is for ENG and non-computerized, strip-chart recording systems. That might be difficult to see. That will give the patient a sensation of rotation toward the irrigated ear and the vestibulo-ocular reflex (VOR) will move the eyes away slowly from the irrigated ear. Figure 8: Unilateral caloric weakness. How many tests for fixation suppression? On occasion, one irrigation is much larger than the rest. So this is a beautiful test about as perfect as they come. Warm irrigations will cause nystagmus to beat toward the irrigated ear. So you had your third, five minute break. Now we've reached zero. Learn more: Pediatric vestibular assessment (rotational chair focus) Pitfalls and artifacts By its nature, caloric testing is susceptible to artifacts. After that, perform 40-second irrigations for all the remaining irrigations. The criterion is a fixation index of either 60% or 50%. So she's suppressing the response, which she did. So already at this point, I have an indication of what the overall result might be, which for you is 17%. This causes a bit of a temperature effect. (1980). The main aspects on the use and interpretation of caloric testing are reviewed. And for directional preponderance, she got 9% left beating, which is again, well below the 30%. Caloric test procedure Now we’ll cover the test procedure, step-by-step. Plural Publishing. So you still feel like you're spinning quite a lot. Like you're turning towards me a little bit? So that's good. And I on the software screen now have a mono-thermal warm screening threshold. It should however be noted that this can be unpleasant for the patient. So we can see that all four of the caloric tests were done. We must make sure that we eliminate or recognize them before we interpret them. still okay. (1998). Due to the thickening of the tympanic membrane, otosclerosis or other middle ear changes, caloric irrigations might generate minimal responses. For example, the rotational chair in the sinusoidal harmonic acceleration test can go from a very low frequency such as 0.1 up to 1.28 Hz, which is in the physiological range of the human VOR. Let's try T. 119-131). I'm just gonna get in here and get a good look. When interpreting the caloric response, you can perform a series of analyses that can answer the questions about the status of the peripheral vestibular system, the lateral semicircular canal function, and the associated central connections. Now we're going to do the second one on the test. In this case, the left lateral semicircular canal. If it was an acute lesion, you'd see all the irrigations shifted to one direction due to the presence of a spontaneous nystagmus. Okay, so I'm gonna put the cover on again. Now we're getting ready to perform the caloric test. Very good. This guide provides clinicians with a complete introduction to performing and interpreting the caloric test. So nothing should be happening yet. Now tell me what you feel like feel. In this patient, especially for right irrigations, the fixation suppression is abnormal (Figure 12). Take a look right once I got a nice view of your eardrum, I'm gonna start the test. Remember, don't close your eyes. Once the response begins to subside, you should ask the patient to fixate. You can relax these conditions a bit if you're including another test. So, it's most likely because of heat transfer issues in older individuals and you should be aware of that. Be aware that some air irrigators do not cool the air. And then just 31 degrees of overall nystagmus. The response will reach its peak and then starts to subside, which usually occurs about 40 to 45 seconds after the end of the caloric irrigation. First, get a really good look in your ear. This is due to the heat transfer issues mentioned earlier. And so what's going to happen is I'm going to have this, what's called an irrigator, behind me, and it has an otoscope, like, what the doctor looks at in your ear with, right, but it's going to be blowing some air. Utilizing cervical and ocular VEMP in the assessment of peripheral vestibular function allows us to determine if the gravity-sensing organs of the peripheral vestibular system are also indicating reduced or absent function. Analysis and interpretation of the caloric test In this section, we’re going to go through what a normal caloric response looks like, and common abnormalities seen in the assessment. Okay, so to the left, which is correct. The fixation index is a measure of nystagmus intensity during fixation compared to the nystagmus right before fixation. Physiology of the caloric test For caloric testing, you should place your patient in a supine position with their head – or upper body – elevated 30 degrees (Figure 1). So stare right at that light. Okay, just a few more seconds. So at times zero, there was no response because it's taking a while for the irrigation to heat up the fluids. There are different criteria, but in this case, we’ll use a total response in each ear of less than 12 degrees per second. We finished both of the warm irrigations. Okay. What can cause bilateral weakness? You take the total right-beating nystagmus and subtract the total-left beating nystagmus. That's great. In Figure 9, the patient has 9 degrees per second of left-beating, spontaneous nystagmus. So as soon as it beeps, we'll be ready to go. For VNG, calibration between irrigations might actually create more variability, so it's not recommended. And then the only other thing that's important to look at on the screen is here you can see this yellow bar. In a normal caloric response, we would expect the: Velocity profile of the caloric response to start to increase in amplitude approximately 20 seconds after the onset of the caloric irrigation. I come in here. (1942). In this method, you irrigate the external auditory canal in each ear twice. One might consider this value as the gold standard for detecting vestibular abnormalities. So now we're down to the last 10 seconds. The test is complete when each ear has received both a warm and a cool irrigation – so 4 irrigations in total. Sometimes, even from one ear to the other. Feeling okay? Okay, so don't close your eyes. If you run out of names, I'll throw another letter out. That process is never perfect regardless of which system you use. Now we're gonna wait for that light to come on. I'm taking the irrigator out. If the patient is cooperative, you can go a bit lower than that. Okay, and then you'll know when we're done with the test, because I'm gonna take the cover back off. All right, so I'm gonna pull the irrigator out. The baseline of all the caloric irrigations will shift in one direction based on the slow phases of spontaneous nystagmus. So the irrigator is now running. We call this caloric-induced nystagmus. They only use the ambient temperature, so if you're in a warm climate, you might not be getting cool irrigations. Looks like everything is working just the way that it should. Figure 7: Normal caloric response. And I'm sure you're very happy. It's also been reported to a lesser extent in patients with migraine and motion sensitivity syndrome. This is a test for bilateral, peripheral vestibular lesions. When you see that light come on, just look at it. For the first 30 seconds, you're not gonna feel anything at all. Depending on the type of irrigation, it either ends after 30 seconds (water irrigation) or one minute (air irrigation). Limitations Caloric testing also has some limitations that you should be aware of. That means our irrigator is ready to go. All right. The research literature suggests that in some peripheral pathologies, such as endolymphatic hydrops, the caloric test may show changes in the sensitivity of the peripheral vestibular system in the early stages, so it remains a valuable tool in vestibular diagnostics. If you put them in a caloric pod, they all rise from the baseline of zero degrees per second. Still feel like you're turning the same amount or does it seem to be slowing down a little bit for you? So you start to feel that little bit of that motion again. Elsevier. This usually will produce a robust response due to strong the stimulation. It seems clinicians prefer air, and this is likely due to its advantages as we discussed before. There's no upper age limit, but you should realize that irrigations may not be as effective in older patients. There it is. Example of a unilateral caloric weakness So this is an example of a patient that has a unilateral caloric weakness, and we can see her irrigations. The terminology that we use is x percentage of unilateral weakness in the weaker ear. When you're staring at the light, the response should feel like it gets a little slower for you. Okay, very good. There's no error in the test. Of course, you have to do that before the patient gets to a point of no return. Sarah, Sophie, Simon. For example, if somebody has a tumor at the cerebellum, that's blocking the neural firing from reaching the central nervous system. Hey, now the light's gonna go off. These patients might have a bilateral vestibular loss. There's a good basis on why you should start with warm. It's usually the last test that we do in the VNG test battery. That's the time period where the fixation light came on. All right, then I want to put the cover on and we're gonna get ready to start the test. I'm here to help you. The most common etiology is unknown, but among the known causes are: Idiopathic Ototoxicity Bilateral Meniere's disease Cerebellar degeneration and tumors Congenital malformations such as Chiari malformation Hyperresponsiveness Hyperresponsiveness, also known as hyperactivity or hyperfunction, is a rare finding in the caloric test. Feeling any rotation yet? D., Akin, F. Let's relax for a second. Let's rest a little bit, see if we can slow that response down. This time toward the irrigated ear with the fast phases directed away from the irrigated ear. Our last time should start to slow down that motion pretty soon. So I want to bring that into your ear. So nothing is happening. We’ll address the topic of sickness during caloric testing later in this article as there are procedures that you can follow to reduce patient discomfort. Your second test is done. Unilateral weakness The most common abnormality in the caloric test is a unilateral caloric weakness (Figure 8). Any questions? Away from you. Warm irrigation in left ear Okay, so there's the beep. It sounds kind of loud, but you'll eventually tune that out. You do this for about 10-15 seconds and then turn off the fixation light. That makes it very effective for detecting unilateral vestibular losses. Task to keep the patient busy Okay, one other thing that we're going to do is, I'm going to give you a task. Let's take a rest. P., Furman, J. (Ed.), & Lempert, T. If you look at the patient from the front, you can see the orientation of the semicircular canal. You're doing good. In reality, not much. Yes, about equal that's good. Okay, let's start your tasking. 5. If the patient is getting too distressed, you can sit the patient up and turn the head 30 degrees downward. So we can see the nystagmus slow phases are very small, with both right cool and right warm significantly larger than left warm and left cool. Thank you. What is directional preponderance? The British Society of Audiology, which also has standards for caloric testing, matched the ANSI standards early on but have later reversed their recommendation when the eye movement measurement technology moved to VNG. The bi-thermal caloric test was introduced into clinical practice in the early 1940s, mainly because of the development work of Fitzgerald and Hallpike (1942) [1]. [6] Noaksson, L., Schulin, M., Kovacsovics, B., & Ledin, T. For both directions of nystagmus, this patient would also likely have some form of tracking abnormality in the smooth pursuit test. In the old days, there was some discussion over caloric perversion. There's no sensation of motion or any type of nystagmus in a normal individual. Warm irrigations If you start irrigating the external auditory canal with a warm medium (Figure 4), the area of the semicircular canal that's closest to the external auditory canal is going to heat up. That's completely normal. And any minute now, we should see the fixation light, there it is. Okay, so you feel like you're turning towards me? And a few seconds, that response should start to slow down a little bit. Yes, that's a good normal thing. Perfect. In this case, the irrigated ear has a higher neural firing than the non-irrigated ear. When it shrinks, you know that the patient is actually fixating. There are occasionally nystagmus beats that are either missed or falsely verified. Okay, that's great. It involves introducing a stimulus into an ear which either heats it up or cools it down, creating a temperature gradient. Results interpretation Okay, so we've completed the caloric test. W., Lynn, S. For example, caloric testing is not the most effective test in patients with bilateral vestibular hypofunction. Caloric test technique Now, we’ll take a deep dive into the techniques behind warm and cool irrigations. A systematic review ... And so far, so good. 3. Figure 12: Failure of fixation suppression. We're on the last one. You're just gonna hear that noise and you're gonna feel that warm air. If you're doing it correctly, both irrigation methods will generate acceptable results with good test, re-test reliability. What can cause a unilateral weakness? Usually, the one that has more neighbors is the one you should consider. You can perform another cross-check by assessing otolith function with vestibular evoked myogenic potentials (VEMP). I'm just gonna take the otoscope. Bilateral weakness The next abnormality is bilateral vestibular weakness, also known as hypofunction or hyporesponsiveness. So I'm going to take the cover off and we're gonna take another one of those 5+ minute breaks. Look right at the light. Okay, so in a few seconds, the light's gonna come on. Not well tolerated Another limitation is that the patients usually find the caloric test distressing. Tell me when you start to feel that motion. Okay, which direction are you moving? Remember, you're gonna feel that air now and it's warm. It's kind of warm air. Figure 1: Standard caloric position. Right total is 9 degrees per second. I have 10 seconds left, you're doing really good. Figure 11: Hyperresponsiveness. That's a little more than halfway done. Monothermal caloric screening test performance: a relative operating characteristic curve analysis. So, caloric testing is not an optimal test in the pediatric population. Again, the VOR will move the eyes. It beeped, meaning I can go ahead and start the test. Usually, warm irrigations are stronger than cool irrigations. And then I start blowing that air, which is gonna last 60 seconds. The most common factor is spontaneous nystagmus. And perfect. The most common method for performing the caloric test is the bi-thermal caloric test. This heat transfer therefore depends on the anatomy and other factors. You can then check for any residual nystagmus by assessing eye movements with fixation removed. Very low-frequency stimulation Caloric testing generates very low-frequency stimulation, which is not in the physiological range of the vestibular system. That's good. Left total is 6 degrees per second. We don't do that anymore and it's not recommended. I'm gonna have this cover on the goggles and your eyes are gonna be wide open. Failure of fixation suppression The next abnormality is the failure of fixation suppression. M. As soon as the irrigation ends, you should engage the patient with some alerting tasks so they're awake and alert throughout the rest of the test. But it's a little dotted box there, that dotted box is the peak response. It's just a pure, right caloric weakness. That's the proper angle to have her lateral canals in the right position to allow us to stimulate the ears properly. Again, an extremely rare finding and we don't know what it means because the incidence of it has been so low that we don't have enough information to judge on that. They're more comfortable to the patient as they don't generate as strong a response. Air irrigations have been around for a long time and they're not as messy as open-loop water as there's no water to catch. Is there an age limit for caloric testing? You may be better off looking at the spontaneous nystagmus rather than directional preponderance. This is the most common method and instead of using directional preponderance to diagnose that, you can make a much easier interpretation based on the spontaneous nystagmus. It's seen in patients with cerebral atrophy and diseases that affect the cerebellum. The computer calculates this value. We want everything to be perfect. In clinics today, the preferred method of eye measurement is videonystagmography (VNG), which has advantages over other techniques, especially as it also allows clinicians the ability to observe the eyes during testing. So I'm going to keep you busy after the test is done while I'm recording the data on your eye movements on the software. During this process, make sure you remove clear outliers to clean up your tracings and get a better representation of the average slow phase velocity of the measured nystagmus. [7] Murnane, O. This will put pressure on the cupula and bend it toward the utricular sac. She has 70 degrees. If you repeat the outlier irrigation, it will usually produce results similar to the other irrigations. As the nystagmus slow phase velocity (SPV) is plotted against the time in seconds, you will see the velocity profile of the caloric response has a characteristic shape, rising in velocity before reaching a peak, and then reducing in velocity as the temperature increase caused by the caloric stimulus starts to return to the patient’s normal body temperature. Okay, remember we're going to leave our eyes open at this point. So we're gonna be able to deal with it. Use the one you're comfortable with. It’s important to record for a few seconds after the fixation light has been switched off again. Also, you can generate caloric stimulation with relatively small and inexpensive equipment, compared to a rotational chair for example. In the old days, we used to do bilateral ice water testing. 2. The right cool and the right warm responses are very small compared to her responses on the left side, where her responses were much larger. Fixate on light And then one last thing is that after I've stopped the irrigator, and you're doing your naming, and I'm looking at your eyes, about 10 or 15 seconds into that process, a light is going to come on inside of the goggle. We’ll cover each below. And it's gonna feel a little bit warm, I'm gonna start blowing the air in there. All right, keep your eyes wide open for me. It’s a test of the lateral semicircular canals Technically, you can put the anterior and posterior canals in the plane of gravity and try to do caloric testing. So that's enough to really reliably analyze the test because you don't want to have too small a number of responses, because then the calculations suffer a little bit from the numbers being too close together. Normal results Figure 7 demonstrates a normal response. O., & Stockwell, C. The responses are not calibrated This means the responses vary from one person to another. No, I'm good. It’s quite easy for the examiner to perform as water will fill the entire ear canal and will cause a robust temperature increase or decrease in the ear. Oh, that's very good. With technological development, later recording techniques such as electronystagmography (ENG) allowed the responses to be quantified in terms of the slow phase velocity and duration of nystagmus eye movements. Got about 10 more seconds. Caloric perversion is a central abnormality, but it's extremely rare. Okay, as soon as I can see your eardrum. Figure 3: Air Fx air caloric irrigator. What is the fixation index? You did amazing. So 3, 2, 1 and you are finished. Again, try repeating the outlier irrigation. The caloric test compares the results from the right ear to the left ear, so we want the anatomy to be similar on each side. Cool irrigations If you irrigate the ear with a cool temperature (Figure 5), the endolymph will get heavier, and it will sink. And then eventually we start to see these dots or this nystagmus building as we're heating the air and then it reaches a peak. Cool irrigation in right ear Alright, so now we got the irrigator running again, you've just finished your third break. Test procedure Okay, so four all together, warm air, each ear, cool air, each ear and then we'll be done. G., & Cyr, D. And one second left, and zero. In the example shown in Figure 7, they all peak around the SPV of 20 degrees per second, after a period of 80 seconds or more, and then decline. With the cool air you feel like you're turning in the opposite direction. If you have a good calibration, it’s generally unnecessary to carry out further calibration, unless you move the cameras within the goggles or if you remove or reposition the goggles. Caloric test parameters There are three important caloric test parameters that we’ll cover in this section: Unilateral weakness Directional preponderance Fixation index What is unilateral weakness? Okay, so now you might start to feel like you're turning towards me a little bit. Hang in there. Okay, so I'm gonna call out, say, m, and you're gonna say, Michelle, Mary and Mike, and you're gonna try to name as many names as you can. And directional preponderance: were the beats to the right stronger than the beats to the left? By doing so, you can choose the two irrigations where the nystagmus intensities right before the irrigation are approximately the same. Have you started to feel that? This time I’m going into your right ear with some cold air. (Ed.) (2016). That is typically the first warm irrigation. The general idea of the caloric test is that heat or cold changes the density of the water-like endolymph in the semicircular canals. If the patient can manage the first irrigation, they are likely going to be okay for the rest of the irrigations. We are halfway through, so there's another 25 seconds to go. So how are you feeling? Does it feel about the same motion as you felt when we did the other ear? Should you use air irrigators? But in some cases, the caloric test is still the only test that can determine the side of lesion with a high level of confidence. Pay attention to your patient's body responses. That should make the response a little less when you're looking at the light. You have to do a secondary test to confirm a bilateral vestibular loss. Unilateral weakness, also known as canal paresis or reduced vestibular response, is the relative difference between responses from the right and left ears. So, follow the manufacturer's recommendations. [5] Shepard, N. We call that a bilateral weakness. Oh, here we go. Verify nystagmus beats One of the things that happens in the computer analysis is that it tries to verify or identify nystagmus beats and then determine the slow phase velocity of those nystagmus beats. Tom, Thomas, Tom, Tina. A study by Noaksson et al. That's just a task to help keep you busy. If one nystagmus speed shows 20 degrees per second, and the one next to it shows 5 degrees per second, then one of them is not right. Figure 10: Bilateral caloric weakness. All the tests are centered around zero, which means this patient has no spontaneous nystagmus. It's most likely due to the loss of inhibitory responses at the vestibular nuclei. This generates an asymmetry between the two vestibular systems in the inner ears and causes a nystagmus to occur. If their breathing intensifies and you can feel the heat rising from the patient's body, then you know that the patient is under a bit of distress. One quick way of determining that is observing the patient's pupils when the light turns on. In caloric perversion, by definition, all four irrigations must generate either purely vertical nystagmus or vertical nystagmus that's much stronger than the horizontal nystagmus. But in most cases, if you test the patient with a different mode of vestibular stimulation like rotation or vHIT, you'll see that these patients have normal responses. Caloric irrigators Before we discuss the caloric test in more detail, let’s consider the instrumentation to deliver the caloric irrigations. The gold standard would be a rotational chair – at least in the past. The caloric test is referred to in the literature as an extremely low-frequency test, at a frequency equivalent to 0.004 Hz [5]. What is the total response? These are: Unilateral weakness Directional preponderance Bilateral weakness Hyperresponsiveness Fixation suppression We will now look at these components in more detail. I'm gonna go ahead and start the test now. If you look at this patient, they are abnormal (Figure 10). 20 and then the fixation light should come on. Calibration between irrigations In the old days and to this day, the ANSI recommendation is that you calibrate eye movements between irrigations. 1. After about 30 seconds, the fluids inside of your ear are gonna start to move because I've heated them up. Because the tonic neural activity in the opposite ear is higher than this, the patient will feel like they're rotating toward the non-irrigated ear or away from the irrigated ear. And you're doing fine. In most cases, there's a much simpler explanation than caloric perversion. So here we go. Let's start with the letter M for Michelle. This type of cupular deflection away from the utricular sac will cause inhibition of the semicircular canal and the neural firing will decrease. Right there. So it's not too bad yet, right now starting to get a little faster. The criterion is not very clear. If the patient isn't cooperative, you probably have to go higher than that. In turn, the endolymph in the semicircular canal will get lighter and it will rise. In the calculations, you can see a 64% unilateral weakness in the right ear, above the criterion for abnormality of 25% (some use 20%). I'm gonna take the cover off now and you're gonna take a break for five minutes. She looks at the light, which reduces the response quite a lot. Directional preponderance is the relative difference between right-beating vs left-beating nystagmus. The change in density then changes the balance of force across the cupula, and this change of force causes ... The results of the caloric test, in terms of the responses to four stimuli, are used to obtain a measure of canal paresis (also known as unilateral weakness) and directional preponderance. Air The second method of irrigating the ear is to use an air irrigator. Yeah, you shouldn't feel anything other than the air. The international tinnitus journal, 4(1), 71–73. T., Jacobson, G. There are two different kinds of caloric irrigators: open-loop water irrigators and air irrigators. Usually, most of the discomfort occurs during the first irrigation. Seven minutes and longer is usually enough, even in a patient who has a strong response. Instructions to the patient before the test Alright, so Tess, we're going to do that caloric test now. 4. Great. We have nice, strong nystagmus responses down here. Figure 6: Unilateral weakness. Then, normalize this by dividing it by the total response from both ears. Tina. One way or the other, by repeating, the weakness will increase, indicating a true unilateral weakness, or it will decrease, indicating a normal finding. Unilateral weakness is a peripheral vestibular lesion involving the lateral semicircular canal or its efferent pathways on the weaker side, which is usually the superior part of the vestibular nerve. For example, if you were in the middle of a one-minute irrigation, but you only did 40 seconds, make a note of 40 seconds and allow time for the patient to recover. I want you to name somebody's name for me that starts with the letter C as in Charlie. Record spontaneous nystagmus Once the patient consents to the procedure, it’s important to record any nystagmus in the caloric test position. You might think that the patient has a bilateral weakness, a deterioration of the vestibular system due to age. In other words, if you want to do monothermal calorics, they are more effective with warm irrigations. After 15-30 seconds of irrigation, you will begin to see a nystagmus begin to generate and then increase in size. Handbook of Balance Function Testing. If it doesn’t change, repeat the other temperature on the same side, as there may have been inadequate irrigation. So now I want you to just stare at that light for me. A study by Murnane et al. And then we're going to take a break for four or five minutes, and then we'll proceed to do the second irrigation. We heard the beep in the background, so we are ready to go. I'm going to put the cover on the goggles. What does bilateral caloric weakness mean? Then you normalize it by dividing by the total beating nystagmus from both ears. Cool irrigations will generate nystagmus that beats opposite to the direction of the irrigated ear. That's good responses. And so you're gonna start to feel like you're turning over. (2019). And now the light's gonna go off again. Are you ready? There you go. With the introduction of the vHIT, the need for doing a full, bi-thermal caloric test has somewhat diminished. We had a healthy, normal response on this patient. The total response from each ear, signified by the opening of this pod, is much smaller for the right ear. Advantages Unlike head movements, you can deliver caloric irrigations to each labyrinth independently. Most VNG goggles have a light built into them on which the patient can fixate, and you can look at the patient's pupil. (1993). The lower age limit is five years of developmental age in children and adults with developmental delays. In an uncompensated or acute version of this, it could be: Vestibular neuritis Viral or bacterial labyrinthitis Initial episodes of Meniere's disease Labyrinthine concussion or infarction In a compensated or chronic version of this, it could be: Vestibular neuritis Viral or bacterial labyrinthitis Late stages of Meniere’s disease Vestibular schwannoma or acoustic neuroma Central lesions that affect the root entry zone of the vestibular nerve – such as multiple sclerosis (MS) – can cause unilateral weakness but other central-nervous-system (CNS) signs will also be present. Often, it's a bilateral loss of peripheral function in both ears, but you can also have central abnormalities that cause bilateral weakness. Keep your eyes nice and wide open. When the test starts, the irrigator delivers a stimulus into the ear and the software will begin recording the eyes. Don't worry, there's no right or wrong answer. Right and get a good look in your ear, okay. We can see that the time is going this way. Chapter 9 - The caloric irrigation test. G. If the total responses are too small, then the other calculations become inaccurate. 137, pp. It’s possible to use monothermal warm calorics as a screening test, primarily to identify normal calorics. Remember to keep your eyes wide open for me. This kind of cupular deflection in the lateral canal would cause excitation of the semicircular canal. They recommend either open-loop or closed-loop water. This head position will place the lateral semicircular canals in the plane of gravity. (2009). If the heat transfer is disrupted through the middle ear, this can result in what appears to be a bilateral weakness, but this doesn't mean that the vestibular system is abnormal, as the caloric stimulus might not have reached the end organ. And your letter is S for Sam. Which way do you feel like you're turning this time? In Handbook of Clinical Neurology (Vol. All right, let me get a look in there. W. The air irrigator by Interacoustics is the Air Fx (Figure 3) and has the following temperature range: 20 to 50 degrees Celsius. Which way towards you? If the patient's pupils shrink, that means the light is being observed, but the patient still must concentrate to suppress the nystagmus generated in the caloric test. Just take a stare at that light for me. And that gives us this calculation for unilateral weakness, which is the difference between the ears. Okay, let's try the letter D as in David. So her calculation shows a 55% unilateral weakness and a very small amount of directional preponderance. [2] Barber, H. When there's no irrigation, the neural firing from both the right and left ears are approximately the same. Figure 2: Aqua Stim open-loop water caloric irrigator. Temperature Order Effects in the Caloric Reaction. Related courses References [1] Fitzgerald, G., Hallpike, C. Wait period between irrigations As for how long you should wait between irrigations, ANSI recommends a fixed period of time of around five minutes between the start of consecutive irrigations. If you use the standard parameters, your false positive rate will be very high. Okay, yes. Peak nystagmus amplitude at approximately 60 to 90 seconds and then begin to decline. We're gonna now wait again for that fixation light to come on. The most common formula is the slow phase velocity right after fixation divided by the slow phase velocity right before fixation. Clinicians have not followed the recommendation, with a ratio of air to water irrigator sales at about four to one. That's a good recommendation, especially if you decide to do just two irrigations. So good for you. Tess has taken a 5+ minute break to let her ear cool to room temperature. And my software is now going to show me a final response, which looks very normal. If it exceeds that, you should consider it abnormal. [4] McCaslin, D. So, we need to do this for both right-beating and left-beating nystagmus because fixation suppression can be normal in one direction but not the other. All four caloric irrigations are approximately the same. Let's try the letter L. Now we're ready to do the very last one. The most likely cause of this is that a slight amount of stimulation reaches the posterior and anterior canals, from which vertical nystagmus originates. When first used, the evaluation of the caloric-induced nystagmus was based upon the observer watching the eye movement and timing the duration of the response. And then the response is gonna pick back up a little bit. There's an extremely rare type of directional preponderance where the irrigation results for one direction of nystagmus are higher compared to the other direction without any substantial nystagmus. Thomas. And let's start our task again. In this example, cool irrigation will cause right-beating nystagmus as we're irrigating the left ear [2]. Megan. For example, we say 64% unilateral weakness in the right ear. This can be caused by diseases that affect the labyrinth, the vestibular nerve, or the blood supply to those sites. The irrigator is cooling off, getting to its temperature of 24 degrees. That's a fair comparison and how you should compare fixation suppression for the right and left. 1. Down to five seconds. Away from you? Brain, 65(2), 115–137. One thing you must make sure is that the patient is actually looking at the target. That's a significant amount of spontaneous nystagmus and you should consider it as abnormal. For example, an irrigator where the air freely goes in and out will have a different temperature in the ear canal compared to an irrigator where it seals the ear canal. Studies in human vestibular function: I. Which kind of irrigator is best? Right, very good. Describe the procedure to your patient Before putting your patient in the caloric test position, you should first describe the procedure in non-distressing language. Yes. So remember, whatever you do, don't close your eyes. This is important because if there is a nystagmus present, you should take this into consideration during the results interpretation. Most patients are worried that they’ll be sick, so you need to reassure them that – in most cases – this will not happen. Directional preponderance For directional preponderance, most people use 30% as the limit between normal and abnormal. So what should happen is you have less nystagmus when the light comes on. You take the total responses from the right ear and subtract the total responses from the left ear. Okay, and try the letter T. About 15 seconds left. And then when the light goes off, you can see the response starts to recover. Children that age do not let you put an irrigator in their ear and hold it there for such a long time. So we're doing really well, hang in there. In this case, if this is the left lateral semicircular canal, the patient will have left-beating nystagmus. Okay, so I'm gonna put my hand here so that you know I'm here. So she's able to have what we call fixation suppression. Thus, this is likely a chronic lesion or a statically-compensated lesion. Assess the ear canal and middle ear Before completing the caloric test, it’s important to perform otoscopy and tympanometry to assess the status of the ear canal and middle ear.

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