JOURNAL OF
EMERGING INVESTIGATORS

Article

# Association of agenesis of the corpus callosum with epilepsy and anticonvulsant drug treatment

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## SUMMARY

**Agenesis of the Corpus Callosum (ACC) is a birth defect where an infant's corpus callosum, the structure linking the brain's two hemispheres to allow interhemispheric communication, fails to develop in a typical manner during pregnancy. Existing research on the connection between ACC and epilepsy leaves significant gaps, due to the lack of focused investigation. One important gap is the degree to which ACC may impact the course of epilepsy treatment and outcomes. The present study was conducted to test the hypotheses that epilepsy is highly prevalent among individuals with ACC, and that those with both ACC and epilepsy have a lower response rate to anticonvulsant drugs than other patients treated with anticonvulsant drugs. A weighted average of epilepsy rates was calculated from a review of existing literature, which supported the hypothesis that epilepsy was more common among individuals with ACC (25.11%) than in the general population (1.2%). An empirical survey administered to 57 subjects or parents of subjects showed that rate of intractable epilepsy among study subjects with both ACC and epilepsy was substantially higher than the rate found in the general population, indicating that individuals with both conditions had a lower response rate to the anticonvulsant drugs. This study contributes novel results regarding the potential for concurrence of ACC and epilepsy to interfere with anticonvulsant drug treatment. We also discuss implications for how medical professionals may use the findings of this study to add depth to their treatment decisions.**

## INTRODUCTION

The corpus callosum is the structure linking the brain's two hemispheres that allows for interhemispheric communication. Agenesis of the corpus callosum (ACC) is a birth defect where an infant's corpus callosum fails to develop in a typical manner during pregnancy. It was previously thought to be extremely rare, but access to magnetic resonance imaging (MRI) technology has led to an increase in diagnoses. Contemporary research indicates the prevalence of ACC among children is around 1 in 4000 (1).

ACC can be sorted into four primary types: partial ACC (pACC), complete ACC (cACC), hypoplasia of the corpus callosum (HCC), and dysgenesis of the corpus callosum (DCC) (2). The corpus callosum normally develops from the front of the brain to the back during pregnancy. pACC refers to cases in which the corpus callosum has begun, but not completed, its growth. In most cases, the corpus callosum is fully formed in the front but may be absent toward the back of the brain. cACC refers to cases in which the nerve fibers that form the corpus callosum fail to cross from one hemisphere to the other during gestation, resulting in a complete lack of the corpus callosum. HCC refers to cases in which the corpus callosum has been formed but is thin and has fewer nerve fibers than normal. The first three types of ACC described constitute separate categories. However, the fourth type, DCC, often is used as an umbrella term to describe a range of malformation of the corpus callosum; both pACC and HCC may be included in the DCC (3).

Regardless of the type of ACC, there may or may not be additional brain malformations present. ACC without the presence of other brain malformations is referred to as isolated ACC. The combination of ACC and additional brain malformations is referred to as complex ACC. Most research on ACC has centered on its effects on children's developmental growth. Research indicates that having complex ACC has a larger effect on a child's development than having isolated ACC(4). Common symptoms across all types of ACC include anomalies in fine and gross motor control, coordination, language, and cognitive skills. These symptoms may take years to become recognizable, but many signs of ACC are present within 2 years of life (1). These developmental delays in speech and motor movements are common in patients with ACC throughout adulthood (1). Additionally, while there has been little research on developmental outcomes of each category of ACC, the effects of ACC have been shown to depend on the amount of the corpus callosum present and existing comorbidities (1,2). In most cases, ACC is not treated directly, but rather the comorbidities will be managed for the patient's comfort, such as seizures or motor control (2). The present study focuses on another disorder that frequently coexists with ACC, namely epilepsy (5,6).

Epilepsy is a disorder marked by unpredictable seizures (7). Roughly 0.6% of children and 1.2% of all people in the United States have epilepsy that currently requires medical management or treatment (8,9). In contrast to some of the other brain anomalies associated with ACC, epilepsy can be treated by a number of methods, one of the most common being anticonvulsant drugs (7). Anticonvulsant drugs are used to control abnormal nerve cell activity that results in seizures by limiting the excessive electrochemical activity that generally produces seizures. Treatment is considered successful when the patient is seizure-free for 12 consecutive months (10). When epilepsy is still uncontrolled after 2 trials of anticonvulsant drugs, it may be referred to as drug resistant or intractable epilepsy (10). More than 30% of those with epilepsy will suffer from intractable epilepsy (10). Intractable

epilepsy is linked to many damaging outcomes, such as excessive bodily and brain injury. There can also be cognitive and psychological impairment as well as social disabilities if epilepsy is left uncontrolled (11). Death rates are 4-7 times higher in people with intractable epilepsy compared to the general population (11).

Generally, when ACC and epilepsy are studied together, their independent prevalence or relations to other study variables is the focus of the research, hence their correlation is rarely reported (12). Due to the lack of concentrated investigation, there are significant gaps in knowledge about the connection between ACC and epilepsy. One particularly important gap is the impact that ACC might have on a child's outcome in epilepsy management. Epilepsy is a damaging disorder, and finding the correct treatment is stressful and time consuming. However, it is not clear to what extent ACC affects the response to anticonvulsant drugs. If ACC increases the risk for epilepsy to be intractable, the disorder will persist, increasing a child's exposure to greater harm. Addressing the matter of whether ACC increases the risk for having intractable epilepsy could provide greater precision to treatment prognosis and enable patients' guardians to make better informed decisions concerning treatment.

It is important to address gaps in the literature regarding the relationship between ACC and epilepsy, including how individuals with both diagnoses respond to anticonvulsant drugs. The main objective of the present study was to better understand the extent to which ACC is associated with epilepsy, and in particular, intractable epilepsy. We hypothesized that a systematic literature review would indicate higher rates of epilepsy among those with ACC than the general population. We further hypothesized that an empirical survey would show higher rates of intractable epilepsy among those with both epilepsy and ACC than among rates of those with epilepsy alone.

## RESULTS

The first step in determining the likelihood of ACC and epilepsy coexisting was to conduct a systematic literature review. No studies were identified that focused specifically on the relationship between ACC and epilepsy. Following the exclusion criteria, six studies were identified that presented data on rates of both ACC and epilepsy among children.

Results from these six studies varied widely, from 7.62% to 57.00% of the samples being reported to have both ACC and epilepsy (**Table 1**). The percentages of subjects with both ACC and epilepsy for each study were as follows: 45.8% among 24 subjects, 57% among 56 subjects, 35% among 63 subjects, 15% among 162 subjects, 34.43% among 61 subjects, and 7.26% among 105 subjects (6; 11 - 16). In addition to a range of results, there also was significant variability in sample sizes reported in these six studies, and a simple average of results would be biased toward smaller studies. Therefore to control for this bias, the reported percentage of subjects with both ACC and epilepsy from each study was weighted according to sample size. Then an average was calculated from these weighted percentages, yielding a sample size weighted average percentage. This procedure resulted in a weighted average percentage of 25.11% across all six studies of participants who had both ACC and epilepsy (**Table 1**). To estimate the variability of coexisting ACC and epilepsy across each of these sources, we calculated the standard deviation for the percentages reported here. The standard deviation was 18.58%, indicating substantial variability across sources.

The range of results across these six studies may be due to sampling variability (**Table 2**). Researchers might have sampled different proportions of subgroups under the broad term of ACC, or studies may have enrolled participants with highly differing demographic characteristics (e.g., children versus older adults). Despite such variability, our hypothesis that epilepsy is more common among those with ACC was supported in that the weighted average percentage of epilepsy among those with ACC (25.11%) is considerably higher than the percentage rates of epilepsy in the general population of children, 0.8%, and the general population of people in the United States, 1.2% (8) (**Figure 1**).

Thus, there seems to be substantial support in existing literature that ACC elevates the risk of also having epilepsy. To gain further information on ACC and epilepsy, an empirical study was conducted specifically targeting whether concurrence of ACC and epilepsy was associated with intractable epilepsy. Such a correlation could have

| Percentage of Subjects with ACC and Epilepsy | Author and Date |
|---|---|
| 45.80% | Shevell, 2002 |
| 57.00% | Taylor, 1998 |
| 35.00% | Bedeschi, 2006 |
| 15.00% | Romaniello, 2017 |
| 34.43%* | Margari, 2016 |
| 7.26% | Byrd, 1990 |
| **25.11%** | **Weighted Average** |

*Total sample percentage for both isolated (12.50%) and complex (42.20%) ACC.

**Table 1: Percentage of subjects with Agenesis of the Corpus Callosum (ACC) and Epilepsy in existing research studies.** Asterisk indicates total sample percentage for both isolated (12.50%) and complex (42.20%) ACC.

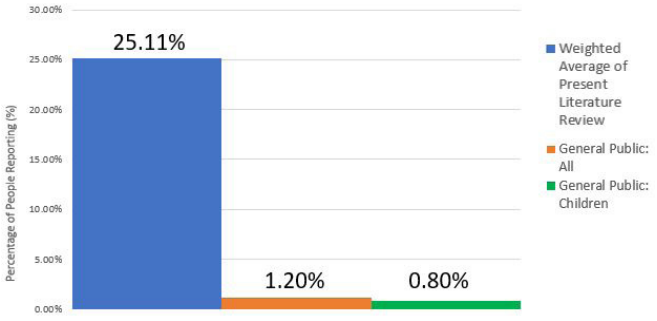


**Figure 1: Prevalence of epilepsy from systematic literature review.** Bar graph showing prevalence rates of epilepsy among those with agenesis of the corpus callosum, the general public, and general public samples of children. Data were gathered through the present research survey and through literature review.

| Source | Sample Size | Age Range | Gender |
|---|---|---|---|
| Shevell, 2002 | 24 | Age not specified | 62.5% M |
| Taylor, 1998 | 56 (36 were adults) | Adult Mean Age: 37.7<br>Child Mean Age: 5.5 | Adult: 67.6% M<br>Child: 60.0% M |
| Bedeschi, 2006 | 63 | Mean Age: 2 years and 7 months | 57.1% M |
| Romaniello, 2017 | 162 | Age at last evaluation: 4 months – 32 years | 56.0% M |
| Margari, 2016 | 61 | Mean Age: 8.8 | 47.5% M |
| Byrd, 1990 | 105 | 0-13 years | 50.5% M |

**Table 2: Sample characteristics of the reviewed literature.** From the referenced studies, characteristics of sample size, age range, and gender distribution of the study participants are provided.

implications for treatment course and recommendations for individuals with ACC and epilepsy.

All 57 subjects in the present study were reported to have ACC. Most subjects were adults reporting about their children, with a small number of adults reporting about themselves. Out of the 57 subjects, 30 were reported to have epilepsy. Thus, a majority (52.63%) had both ACC and epilepsy. Survey and consent materials can be found in the Appendix.

In response to a survey question regarding what type of callosal disorder the subject had, 34 of subjects reported cACC, 15 subjects reported pACC, 4 subjects reported HCC, and 4 subjects reported DCC. This shows that in our sample cACC is by far the most common way that the corpus callosum was affected. This result conforms to previous data, which has found there is a higher prevalence of cACC relative to pACC in the general public (17). The type of callosal disorder reported was then matched to whether the subject also reported having epilepsy. Of the 34 subjects who had cACC, 14 also had epilepsy, whereas 10 out of 15 subjects who had pACC had epilepsy. All four of the subjects who had DCC also had epilepsy, whereas 2 out of 4 of the subjects with HCC had epilepsy (**Figure 2**). A chi-square test was conducted to ascertain whether those with pACC were more likely to have epilepsy. The chi-square test approached statistical significance with a $p$-value of 0.10 but did not reach conventional significance levels of $p < .05$ ($X^2$ (df = 1) = 2.71), indicating a trend for subjects with pACC to be more likely to have epilepsy than those with cACC.

Of the 14 subjects with cACC, 10 had intractable epilepsy. Of the 10 subjects with pACC, 4 had tried one anticonvulsant drug with unsuccessful results but had not tried a second drug. They were therefore excluded from the analysis of subjects with intractable epilepsy. Of the six remaining subjects with pACC, three had intractable epilepsy. None of the participants with HCC had intractable epilepsy, whereas all of the participants with DCC reported having intractable epilepsy (**Figure 3**). Although sample size prevented statistical analysis, in our sample, more patients with DCC had intractable epilepsy than those with pACC and HCC, which would be consistent with an interpretation that agenesis affecting a larger area of the corpus callosum is more severe with regard to epilepsy treatment.

As might be expected for a complicated condition like epilepsy, subjects were reported to have attempted numerous anticonvulsant drugs. Thirty participants reported trying at least one anticonvulsant drug, 20 reported trying two drugs, 16 reported trying three, 11 reported trying four, and nine reported trying five or more anticonvulsant drugs.

The survey found that 66.67% of patients with ACC were nonresponsive to the first anticonvulsant drug tried (**Table 3**). This was compared to six other studies relating

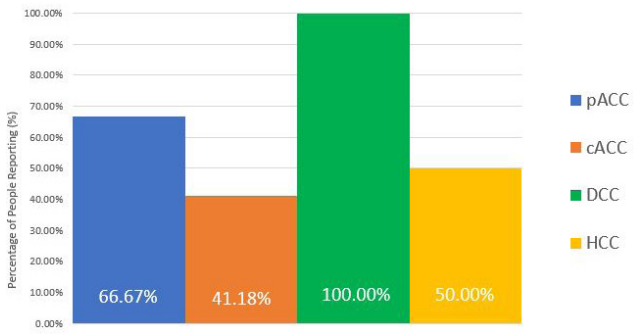


**Figure 2: Rates of epilepsy in subjects with different types of ACC, as determined by the conducted survey.** Bar graph showing prevalence rates of epilepsy among those with the four most commonly used categories of agenesis of the corpus callosum.

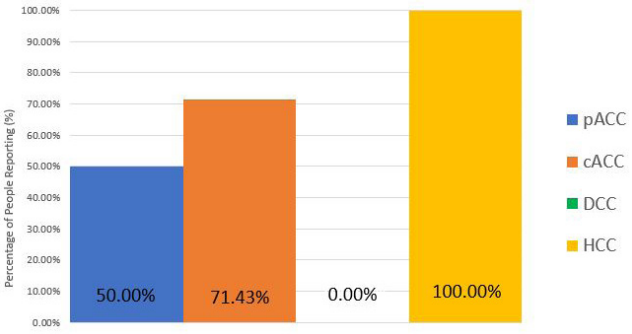


**Figure 3: Rates of intractable epilepsy in subjects with different types of ACC, as determined by the conducted survey.** Bar graph showing prevalence rates of intractable epilepsy among those with the four most commonly used categories of agenesis of the corpus callosum.

| Drug Number | Number of Subjects (n) | Number of Non-responsive Subjects (X) | % non-responsive to drug number (X/n) |
|---|---|---|---|
| 1st | 30 (cohort) | 20 | 66.67% |
| 2nd | 20 | 16 | 80.00% |
| 3rd | 16 | 14 | 87.50% |
| 4th | 11 | 10 | 90.90% |
| 5th or more | 9 | 9 | 100.00% |

**Table 3: Percentage of subjects with nonresponse to anticonvulsants and the number of drugs tried from the present study of ACC and epilepsy.** For survey participants who reported trying more than one anticonvulsant drug, the non-responsivity of the participants to the drugs tried increased with the number of anticonvulsants tested.

to the likelihood of failure of the first anticonvulsant drug in those with only epilepsy. These studies reported a range of percentages of nonresponsive epilepsy from 10.00% to 53.00% (10, 19) (**Figure 4**). Thus, we found a higher level of nonresponsive epilepsy in our sample of patients with both ACC and epilepsy than has been reported in research on individuals with epilepsy alone.

Of the 30 subjects who had tried one anticonvulsant drug, 20 subjects had tried two or more drugs. Of these 20 subjects, 14 (70.00%) had said the 2nd anticonvulsant drug was only somewhat, or not successful, meaning that seizures persisted to a notable degree even if they were reduced by the trial of a second drug for some participants. Failure of two anticonvulsant drugs to eliminate or drastically reduce seizures is the threshold for determining whether someone has intractable epilepsy or not. Two corresponding studies were found concerning response to a second anticonvulsant drug and epilepsy. The studies showed the following percentages of nonresponse: 29.00% and 63.30% (21, 22) (**Figure 5**). The higher percentage of nonresponsive epilepsy in our study supports our hypothesis that people with ACC and epilepsy may be at increased risk for seizures that are nonresponsive or more difficult to treat with anticonvulsant drugs.

## DISCUSSION

The present study was conducted to shed light on the relationship between ACC and epilepsy, as well as on the effectiveness of anticonvulsant drugs in individuals with both ACC and epilepsy. To our knowledge, this specific topic of research has not been studied by the scientific community so far. If better explored, this area of research may potentially provide guidance on the most effective path to treatment for individuals with ACC and epilepsy in the most timely and efficient manner.

The main set of results from this survey show that people with ACC may have a heightened risk of being diagnosed with epilepsy and even greater risk of having non-responsive or intractable epilepsy. A systematic review of the literature showed that children with ACC have a higher percent chance of having epilepsy than the general population of children. We then conducted an empirical survey that showed a higher rate of non-responsiveness to anticonvulsant drugs among individuals with ACC and epilepsy than the general population of individuals with epilepsy.

Due to the design of the survey, it was also possible to explore how outcomes may have been linked to specific types of ACC (pACC, cACC, DCC, and HCC). Our survey found that participants with pACC had a trend toward greater risk of having epilepsy than those with cACC. This difference was not found to be significant in our sample, but replicating this research with a larger sample would likely shed additional

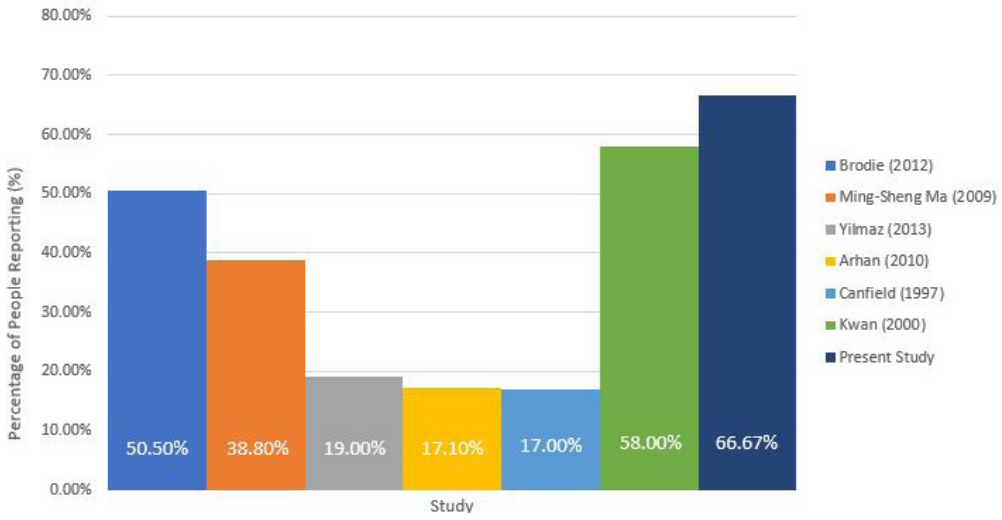


**Figure 4: First anticonvulsant drug nonresponse percentages from various studies of individuals with epilepsy.** Samples were generally children with epilepsy receiving treatment in clinical settings, although Kwan (2000) presented severe epilepsy. Bar graph showing the percentage of the population that was reported to be nonresponsive to the first anticonvulsant medication treatment attempted across six published research studies and the present study. Data were gathered through the present research survey and through literature review. To our knowledge, our surveyed sample is the only one in which subjects had both epilepsy and ACC.

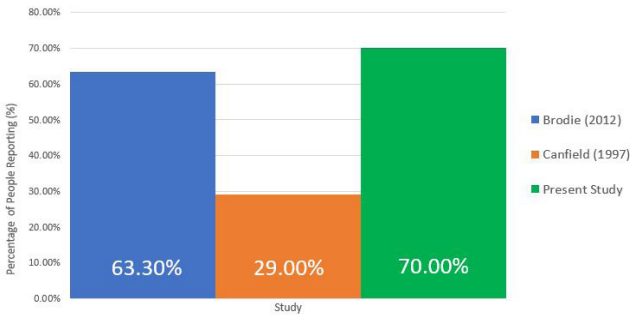


**Figure 5: Second anticonvulsant drug nonresponse percentages from various studies.** Bar graph showing the percentage of the population that was reported to be nonresponsive to both the first and the second anticonvulsant medication treatment attempted from two published research studies and the present study. Data were gathered through the present research survey and through literature review.

light on the extent to which rates of epilepsy differ across types of ACC.

Although the number of subjects with DCC was low, all four such subjects were reported to have epilepsy. Subjects with DCC also reported high levels of unresponsiveness to anticonvulsant drugs, as three out of three were marked as having intractable epilepsy (the fourth subject with DCC had only tried one anticonvulsant that failed, so this subject was not included in the study). This shows that at least among the small number of the participants in this study, people with DCC seem to have increased risk of having both epilepsy and intractable epilepsy.

Similar to patients with DCC, the number of subjects with HCC was low at only four subjects. Two of these subjects had epilepsy; however, none of them had intractable epilepsy. This may indicate that children with HCC have a lower risk for intractable epilepsy overall. However, further investigation is necessary, as literature review uncovered no other research on the relationship between HCC and intractable epilepsy.

There may be some treatment implications of the present research. Medical professionals may use the results of this study to add depth to their decision making when treating a patient with ACC and epilepsy. If one's doctor can anticipate the patient's response to anticonvulsant drugs, there may be a significant change in the treatment strategy (20). Better anticipation of potential lack of response of an epileptic patient with ACC to drug treatment can lead to earlier recognition of the need to change the course of treatment. For example, an improved diagnostic process may lead to quicker progression in the treatment hierarchy and a subsequent reduction in exposure to both ineffective drugs and the detrimental consequences of uncontrolled epilepsy.

Should future research confirm that people with pACC are at a greater risk for epilepsy than people with cACC, physicians and family of patients with different types of callosal disorders would be able to monitor and treat the patient's epilepsy in a more knowledgeable way. For example, physicians may wish to inform parents of children with pACC about the heightened risk their child may have for epilepsy, based on their type of ACC. In the present study, one participant had reported that their child had not yet had a seizure, but due to abnormal electrical activity in the brain, the physician had advised them to place their child on an anticonvulsant proactively, so that they would not have seizures later on. Wider adoption of this type of monitoring might occur more frequently if additional risk from a specific type of callosal disorder is confirmed.

The findings of this study are valuable to families in two ways. First, families of children with ACC can add more specificity to the prognostic information they are given regarding the likelihood that their child might develop epilepsy. This will allow them to monitor their child more closely for early signs and seek out consultation from health professionals to address emerging concerns. Second, families whose children with ACC have been diagnosed with epilepsy will have more specific information on the likelihood that their child will be responsive to anticonvulsant drug treatment based on their diagnosis of ACC in general and possibly, their specific type of ACC. Information is powerful for families as it reduces anxiety and allows them to be a more productive partner with physicians in their child's treatment planning. Families may be more open to exploring alternative options to anticonvulsant drug therapy earlier in the course of treatment if they are aware that their child is at heightened risk of being non-responsive.

As with any study of a rare or uncommon condition, there are limitations both in terms of acquiring large samples and in the depth and quality of the information collected. In this study, the sample size was somewhat low, which may reduce the reliability of the data found due to the potential of a small number of individuals to sway the distribution of the data, and by extension, the conclusions reached. Future research may consider it to be beneficial to find additional methods for distributing the survey to more individuals. Approaches could include partnering directly with more physicians, specialists, or hospitals that have direct access to this population.

Generalizability was also a problem in the study, as there was no collection of data on where subjects lived or where they sought treatment. Therefore, it is not clear to what degree a full representation of the ACC population was achieved, so it is not possible to rule out that participants were all located within one geographical region, reducing insight about any other location. Location of residence and treatment might also influence how subtypes of ACC are diagnosed and used in treatment planning. For the purpose of this study, DCC was defined as the corpus callosum being malformed in some way other than cACC, pACC or HCC; however, there is variability in how the term DCC is used in the literature. In some reports, DCC is used in reference to a range of ACC that other reports specify as HCC and pACC (3). Use of these definitions may not be standardized in all settings. Being able to obtain a sample in which the proportion of subjects with ACC subtypes mirrored those found in the general population would be better for assessing risk due to subtype. Even such a sample would likely have variability in how subtype terminology is used. Thus, future research might also examine consistency of subtype diagnosis.

Because of difficulty getting data about uncommon conditions and due to concerns regarding the small sample size, we made every effort to preserve all data points collected. This meant that the small amount of responses from adults with ACC was included with the data from adults about their children. An additional round of analyses may be performed in the future with these responses removed to get an exclusive percentage specific to children with ACC

and intractable epilepsy. Children are of particular interest to the present group of researchers because of involvement in early intervention efforts and higher levels of networking connections with advocacy groups and health care professionals who also are focused on children. However, research on adults with ACC also is greatly needed.

In addition, this was a self-reported survey, which has inherent limitations. In this study, the participants self-reported diagnosis, number of medications tried, and response to their medications on their own behalf or on behalf of their child. This means that information regarding diagnosis, for example, was subject to participants' recall and degree of understanding of the information provided by medical professionals. Future researchers would ideally look to obtain information from medical records. However, if there is no access to medical records, there are other measures that could be taken to increase the accuracy of information provided through self-reporting. When asking about the diagnosis of the subject, a question to ensure reliability could be to ask the information upon which the participant is basing their answer, such as whether the diagnosis was provided by their doctor or reached through other means. Another way to confirm information could be to ask the participant to list additional details about the medications tried, including the name, dosage, length of trial, and if side-effects played a role in the decision to continue the medication.

Despite inherent limitations, this study added key information to the fields of ACC and epilepsy. The results provide novel data on a previously unresearched area and have direct implications for the health and development of children and others with callosal disorders. By filling in the gaps of previous research and identifying possible patterns of epilepsy and response rates to anticonvulsant drugs among people with the four subtypes of callosal disorders, the present study encourages important new directions of research into the relationship between ACC and epilepsy. Future research should focus on recognizing the different categories of callosal disorders and, even more importantly, the potential for different prognosis and treatment response when those disorders overlap with epilepsy.

## MATERIALS AND METHODS

To identify studies to include in the review, a literature search was conducted using the PubMed and Google Scholar databases with the following keywords: Agenesis of the Corpus Callosum, Epilepsy. A total of 462 studies were found relating to these search terms with both search engines. Efforts were not made at this stage of the review to eliminate duplicate entries or entries that were not peer-reviewed articles. From these, a small number of studies were found to include some measurement of either seizures or epilepsy within the course of a larger investigation of ACC. The principal interest of this review was to focus on the specific link between ACC and epilepsy. Therefore, studies in which the independent contribution of ACC to epilepsy was impossible to determine were eliminated, following several exclusion criteria: studies with fewer than 20 participants total, studies that included participants with multiple other diagnoses that also may cause seizures or have a known link to epilepsy (such as Aicardi syndrome), studies where only the abstract was available, or studies in a language other than English.

Reports on percentages of participants with ACC were tabulated for ACC in general, regardless of possible subtype of ACC participants may have had or that may have been reported in each article.

To assess patterns of anticonvulsant drug use among individuals with ACC, a questionnaire was created on a SurveyMonkey website. Prior to conducting the present research, all study materials and methods were approved by the human subjects research Institutional Review Boards of the Longs Peak Regional Science Fair and the Colorado Science and Engineering Fair. The participants in the empirical study consisted of 57 individuals who provided responses to a 10-question survey. Most (n = 50) subjects were children, for whom their parent or guardian completed the survey, and four were adults (3 participants skipped this question). The average age of the participants in this study was 10 years old. Gender was not reported in this study. All participants about whom data was provided were reported to have ACC.

Participants were recruited using several means. Links to the survey were distributed on a social media platform (Facebook) to groups organized around people who have ACC or who have children with ACC. Emails were sent to professionals in the field of ACC and epilepsy to request contact information for potential participants and also to request that they send the survey link directly to potential participants should they prefer to use that recruitment method. Finally, emails were sent to different agencies and organizations that work with people who met the criteria. The survey was left open for one month. Respondents were asked to provide the age of the individual with ACC, who they were reporting for (child or self), type of ACC (Complete, Partial, Hypoplasia, Dysgenesis, or other), and whether or not the subject had epilepsy.

When subjects reported the presence of epilepsy, they were then prompted to report on the number of anticonvulsants that had been tried using the reporting options of 0, 1, 2, 3, 4, or 5 or more. For each medication tried, respondents were asked to rate success using the following scale modeled on Karceski (23): "Not Successful" meant seizures never stopped or became worse, "Somewhat Successful" meant slight reduction in number of seizures, or seizures returned over time, "Mostly Successful" meant sparse or significantly reduced seizures, and "Fully Successful" meant no seizures/seizure free. The survey ended with a question asking whether the respondent would like to add any further information.

Several analyses were conducted with the data gathered from the study. First, the percentages of participants who were responsive, and who were not responsive (i.e., intractable epilepsy), to anticonvulsant drugs were calculated. Second, rates of intractable epilepsy observed in the survey were compared with rates reported in previously published research on general populations of people with epilepsy. Finally, the responsiveness of anticonvulsant drugs to different types of ACC (complete, partial, DCC, HCC) was compared and tested using chi-square analyses using SPSS 22.

## ACKNOWLEDGEMENTS

The authors would like to thank Susan P. Koh, M.D., Associate Chief of Clinical Services, Children's Hospital of Colorado who supported this research through mentorship.

**Received:** March 27, 2022
**Accepted:** June 26, 2022
**Published:** February 21, 2023

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