CRISPR Technology and Congenital Disordered Development

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Abstract

People from all over the globe suffer from congenital disorders that inevitably cause lifelong challenges. The purpose of the research is to evaluate CRISPR’s ability to reduce the occurrence of genetic abnormalities in in vitro fertilization. The search for literature was conducted on PubMed and Web of Science. Key phrases that were searched were CRISPR-Cas9, CRISPR-Cas9, in vitro fertilization, IIV, and congenital disorder. Several articles were selected assessed CRISPR’s use in editing selected genomes. Two other articles described how CRISPR was implemented within their individual studies. Overall, the common theme within the articles is that genome editing in in vitro models is possible with CRISPR technology. Therefore, there is the possibility that as technology advances, we might see fewer congenital disorder diagnoses because of genetic modification.

Methods/EBP

As a systematic review following the Johns Hopkins Nursing Evidence-Based Model (Deartholt, & Dang, 2022), this evidence-based practice (EBP) project formed the PICO question: In women undergoing in vitro fertilization (IVF) of embryos suspected of or confirmed to possess congenital disorders (P), will CRISPR technology (I) be effective in reducing the occurrence of disordered development (O)? The Pennsylvania State University libraries website was used to search for current and reliable studies that pertain to CRISPR and IVF. The databases that were accessible through the website were PubMed and Web of Science. Peer-reviewed articles from between the years of 2013 and 2022 were preferred. Keywords and phrases that were used to find relevant articles were CRISPR-Cas9, CRISPR-Cas9, in vitro fertilization, IVF, and congenital disorders. A total of 46 articles were identified. After reading and analyzing the level and quality of evidence, ten studies were selected for the literature review. Two studies describe CRISPR’s abilities, while the other eight evaluate CRISPR use in genome alterations. Selected studies have national and international origins.

Background & Problem(s)

The Center for Disease Control and Prevention (2021) reports that approximately 120,000 babies are born with congenital abnormalities in the United States every year. But what if there was a way that we could prevent these abnormalities that develop in the womb using technology that can change the genes of the growing embryo? Clustered regularly interspaced short palindromic repeats (CRISPR) and Cas9, the scissor-like protein, allow for scientists to identify, cut, and then modify selected targets along genomes.

In vitro fertilization (IVF) is a procedure used to help assist with the conception of a child as outlined by the Mayo Clinic (2022). IVF is done by taking mature eggs from ovaries and fertilizing it with sperm in a lab. IVF is done for a myriad of reproductive reasons, such as infertility, but it is a key procedure for patients with infants at risk of congenital disorder development as the fertilized egg can be genetically screened before implantation. The World Health Organization defines congenital disorders as "structural or functional anomalies that occur during intrauterine life" and claim that they can be diagnosed prenatally, during pregnancy, or after birth (2022).

Research is critical for nurses and other healthcare professionals. Evidence-based research guides the care that nurses provide which is why it is crucial for nurses to become more educated about genetics because of CRISPR rapidly advancing healthcare. Having accurate knowledge is crucial for nurses to help their patients make informed decisions and be able to understand the results of their genomic tests and therapies as well as refer to the appropriate resources.

Evaluating CRISPR’s ability to reduce the occurrence of congenital abnormalities in embryos undergoing in vitro fertilization (IVF) is the goal in researching this topic. An answer would allow for parents of embryos receiving IVF treatment to make informed decisions regarding the embryo's care. Thus, the question being asked in this evidence-based project is: in mothers undergoing in vitro fertilization treatment of embryos suspected of or confirmed to possess congenital disorders, will CRISPR technology be effective in reducing the occurrence of disordered development?

Results

The results of this systematic review provide evidence of successful CRISPR use on both somatic and germ cell lines that underwent IVF treatment. After analyzing the compiled data from the ten studies that were collected for the literature review, the first eight studies displayed cases in which the CRISPR-Cas9 system was effective in removing portions of and repairing selected targets across genomes of animal and human cells. The two other studies demonstrated CRISPR’s ability to alter chosen genomes of animal and human cells and led to overall improved outcomes. From the synthesis of the study, it was evident that genomic editing was possible with the use of CRISPR technology in vitro models.

Overall Evidence Synthesis

<table>
<thead>
<tr>
<th>Level of Evidence Strength</th>
<th>Number of Studies</th>
<th>Summary of Findings</th>
<th>Overall Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I: Systematic review or RCTs</td>
<td>none</td>
<td>This experiment of CRISPR technology is effective in altering genetic mutations but also CRISPR use in vitro models can successfully alter target genetic sequences.</td>
<td>High Quality</td>
</tr>
<tr>
<td>Level II: Experimental or RCT</td>
<td>8</td>
<td>This study’s results demonstrate CRISPR’s capability in modifying a targeted sector of the genome.</td>
<td>High Quality</td>
</tr>
<tr>
<td>Level II: Descriptive, correlational, qualitative, and mixed methods</td>
<td>2</td>
<td>Results from this study describe CRISPR’s ability to modify genomes.</td>
<td>High Quality</td>
</tr>
<tr>
<td>Level III: Descriptive and Qualitative research</td>
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<td></td>
<td></td>
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<tr>
<td>Level IV: Expert-based on non-quantitative evidence</td>
<td>none</td>
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Conclusions

Based on the evidence collected, it can be concluded that CRISPR technology is effective in altering target genetic sequences in in vitro subjects. However, it cannot be determined if this technology is effective in reducing the occurrence rate of congenital disorders in embryos suspected of or confirmed to possess said disorders due to the limitations that come with experimenting on human embryos. Conversation related to experimentation on such subjects tends to propagate ethical dilemmas. These dilemmas often lie in an array of availability, informed consent, and undesired effects. Laws and regulations regarding CRISPR technology, be it federal or international, are lacking in development.

Personal beliefs and religion also play a part in whether it is morally acceptable to be using technology such as this on human embryos. Also, seeing as there are nearly no human trials that have been conducted, it is unclear what the risks and benefits would be of performing this intervention on a developing human embryo. Because of these limitations, there is a lack of information regarding CRISPR available to both the public and healthcare professionals, including nurses. Seeing as nurses are at the forefront of patient care, it is expected that nurses evolve alongside technology. Nursing practice will be impacted by the advancement of genetic technology and the way nurses care for patients will need to be adjusted accordingly. For this reason, nurses should be included in the genetic revision conversation.

Recommendations

These authors recommend:

- More well-controlled and repeatable clinical trials
- Further research in human cells/embryos under ethical review
- Improving the public’s and healthcare professionals’ knowledge regarding genetic testing and CRISPR technology
- Establishing national regulations or improving existing agreements
- Establishing an international global network for gene editing

References