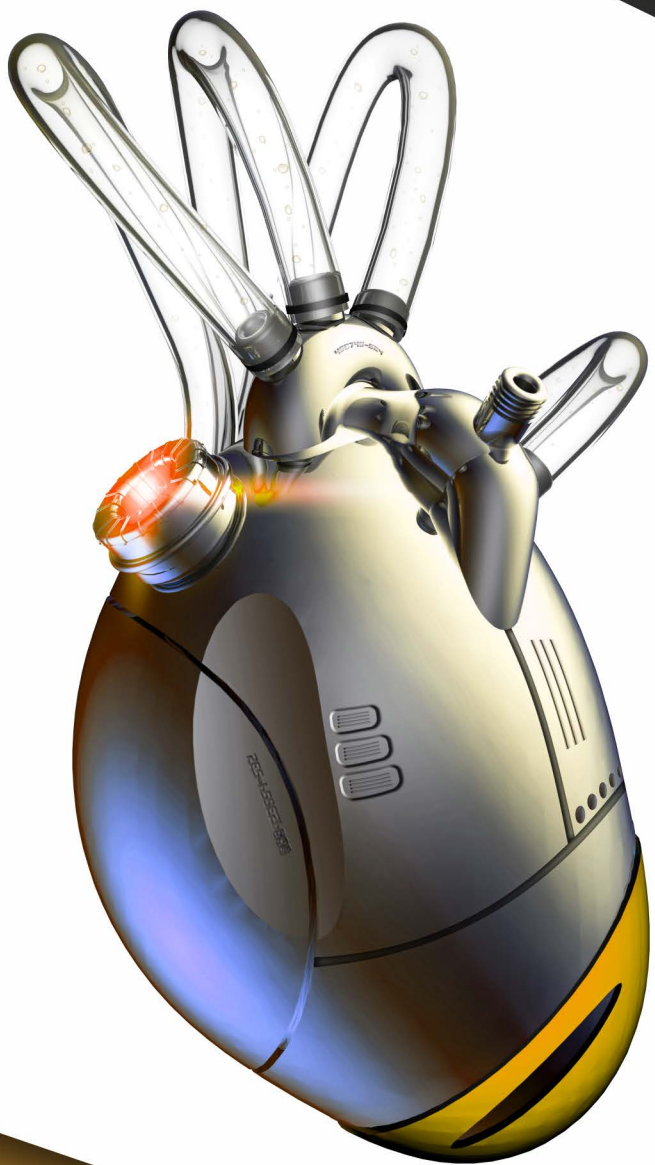
IJABE

International Journal of Advances in Biomedical Engineering

ISSN: 2822-2237
Vol:1, No:2
2022



www.ijabe.online

Volume: 1 No: 2

2022

About IJABE

IJABE is a non-profit organization
Classification of The Journal:Academic/Scholarly
Subject Category: Engineering
Frequency: Quarterly
Format: Online
ISSN: 2822-2237
Language: English
Indexed and Peer Reviewed: Yes
Publisher: Dr. Caglar Cengizler (Cukurova University, ADANA, TURKEY)
Contact: ccengizler@ijabe.online
Address: Adana Organize Sanayi Bölgesi Teknik Bilimler Meslek Yüksekokulu Adana Hacı Sabancı Organize Sanayi Bölgesi (AOSB) Sarıçam/ADANA TURKEY

IN MEMORIAM

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Eren TÜRKUŞAĞI

"Always in our hearts"

Received: 25/04/2022 *Accepted: 28/04/2022*

International Journal of Advances in Biomedical Engineering
Open Access Peer-reviewed Journal
ISSN: 2822-2237
www.ijabe.online
Volume:1, Number:2, Pages:(58-60)
Year:2022

Editorial: Second Issue Of International Journal of Advances in Biomedical Engineering

Founding Editor: Dr. Caglar Cengizler*

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Second Issue in a Nut Shell

We proudly present the second issue of our journal. In this issue, we bring together four recent research articles on different areas of biomedical research. A diverse set of collected topics include animal use in biomedical research, tomography technology, biomedical signal processing and a rare case of ectopia cordis.

Fish are easy to maintain, breed and obtain. Moreover it is relatively easy to set up habitat for fish. These factors would make them ideal experimental animals. In this issue i. Cengizler explains the details of the use of fish as experimental animals in his study [1].

Ectopia Cordis is a congenital defect occurs in the case of location of the heart is outside the thoracic cavity. It is a very rare disease and many studies link it to chromosomal abnormalities. In their article Tepe et al. present a case of Ectopia Cordis and applied intervention [2].

Acoustic analysis is one of the popular biomedical signal processing problems widely tackled for getting more information from the internals of the body. Cengizler and Unal are presenting a study that reveals the spectral features of the bowel sounds [3].

Tomography is a widely used medical imaging modality allow us to monitor body internals by cross-sectional images. Rapidly evolving information technology hardware have increased the imaging potential of tomography. Additionally new machine learning approaches also increase the medical diagnostic capacity of the tomography. C. Cengizler reviews the innovative implementations of nature inspired algorithms in his mini-review [4].

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Received: 02/04/2022 *Accepted: 18/04/2022*

International Journal of Advances in Biomedical Engineering
Open Access Peer-reviewed Journal
ISSN: 2822-2237
www.ijabe.online
Volume:1, Number:2, Pages:(61-68)
Year:2022

Use of Fish As Experimental Animals in Biomedical Research

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Abstract

Factors such as the fact that fish are not difficult to maintain and breed, easy to obtain, and the environment in which they live can be easily adjusted according to demand and number, cause them to be preferred as experimental animals. In addition, the ease of application of drugs and chemicals to be used in experiments (depending on their water solubility) makes the use of fish as experimental animals widespread. However in the case of using fish as experimental animals, first of all, it is necessary to know their basic biological structures very well. Because fishes constitute the lowest group in terms of evolution among the pisces, amphibia, reptilia, aves and mamalia groups in the vertebrata subphylum, and some of their characteristics are quite different from mammals. Evolutionary positions and aquatic life characteristics of fish have caused them to be considered as ideal creatures in the study of both somatic and reproductive and molecular evolution. In recent years, fish have started to be seen as an important experimental model in the field of biomedical, especially in subjects such as embryology, neurobiology, and endocrinology. In this article, information about the use of fish as experimental animals in biomedical research is given, and in addition to this, the historical process of using other animals as test subjects is also examined.

Keywords: Pisces; Animal; Experiment; Biomedical

1. Introduction

When an effect reaches a living thing, different animals are used in order to examine the biological systems and behaviors of that creature according to the variability of the effect. These animals, in which experiments are carried out in vivo, are called experimental animals. It is known that the first experiments on animals were most likely made by Aristotle (384 -322 BC) and Erasistratus (304 -258 BC)[1]. One of the first to apply vivisection, which means the dissection of living animals, was a researcher named Galen, who was a doctor in Rome in the second century. He used goats and pigs as test animals because of the church's strict and strict rules that did not allow human autopsy. For this reason, Galen is called the father of vivisection [2]. Experimental use of animals, which became widespread in the 18th and 19th centuries, continues today on certain rules and scientific foundations. According to a study, nearly 100 million animals, from fish to primates, were used for experimental purposes in 2010 [2]. 93% of the animals used in European Union countries are vertebrate animals [3]. Animals, which are frequently used in biomedical research in human history, have also taken their place in the focus of discussion and criticism, especially due to vivisection. Famous researchers such as Louis Pastor, Robert Koch, Ivan Pavlov, who took their place in the history of medicine, used experimental animals. Likewise, insulin was first isolated from dogs in 1922 and made available to humanity [4]. The sheep Doly, which has the title of being the first mammal cloned in 1996, has brought great controversy [5]. Thus, many countries had to enact laws controlling the experiments. The debates that have been going on for centuries focus on three issues.

1-Results from animals are not suitable for humans. Animals are not suitable for experimental use.

2-During vivisection, the animal may undergo physiological changes and the results may be misleading [6].

3-Even if the experiments are conducted with animal welfare in mind and beneficial results are obtained, it is not ethical in terms of animal rights.

On the other hand, those who see the use of animals in experiments as a necessity see this approach as an indispensable way to produce biological knowledge and advance in medicine[7]. The principles known as the 3R, which were written by Russell and Burc for the first time in 1959 regarding the ethical use of experimental animals, have guided researchers despite all the discussions. These principles are;

1-If there is an alternative method, it should be used instead of the experimental animal. eg computer modelling.

2-Experiments should be planned in such a way that the same level of information can be obtained, and the number of animals used should be reduced.

3- During the experiment, the welfare of the animals should be at the forefront, and methods that alleviate or minimize pain and distress should be applied [8].

According to these principles, if animal testing is unavoidable, the best result should be aimed with animal welfare in the foreground. Today, these three Principles are clearly stated in regulations on animal use. In recent years, organoids

that scientists have produced from human or animal stem cells in vitro can show the structure and physiology of organs such as the brain, kidney, liver, lung, and intestine. In these aspects, they have taken the place of experimental animals. Organoids are widely used in pharmacological and toxicological research [9]. In addition, thanks to the developments in statistical analysis methods and computer technologies, modern imaging and processing techniques reduce the number of experimental animals used. As a matter of fact, the use of dogs and primates as experimental animals has decreased all over the world. However, the most important deficiency and handicap here is that only 37 countries publish their national statistics all over the world. In a study, the number of experimental animals in the world, which was 115.2 million in 2005, was estimated to be 192.1 million in 2015 [10]. Invertebrates are widely used as well as experimental animals. Unfortunately, there are no protective legal regulations for these creatures yet. The most commonly used invertebrate species are Drosophila melanogaster, a fruit fly, and Caenorhabditis elegans, a nematode [11][12]. Rodents are one of the most common vertebrate animals used as experimental animals. Especially mice are preferred due to their size, ease of use, and rapid reproduction. The similarity of their genes to humans is 95% [13]. Other vertebrate groups are also used for different studies. For example, in 2016, around 500 thousand fish and 9000 amphibians were used in research [14]. In addition, rabbits, cats, dogs, pigs and primates are among the most heavily used vertebrates. It is very important to keep the animal welfare at the highest level and to comply with ethical and legal procedures in a research using experimental animals, but it should be noted that it is also a necessity to know the biology of the species on which the experiment will be conducted. In this article, the biology of fish is briefly mentioned and information about their use as experimental animals is given.

2. Pisces

Pisces (fish) form the lowest group of vertebrate animals. If fish are to be used as experimental animals, it is necessary to know the basic biological structures of the fish very well. Because among the pisces, amphibia, reptilia, aves and mamalia groups in the vertebrata subphylum, some features of fish, which constitute the lowest evolutionary group, are quite different from mammals. Pisces and amphibian groups are in the anamnia class as breeding type. These animals lay their eggs in water and fertilization takes place in the water. Other groups are in the amniota class. Amniotic fluid is a fluid that protects and nourishes the embryo. Creatures in the Amniota class have adapted to land life. Pisces, amphibia, reptilia groups are poikilotherm (variable temperature), while aves and mamalia groups are homoiterm (constant temperature). Poikilotherm creatures change their body temperature according to the environmental temperature [15]. Fishes are represented by a group of vertebrates known as ostracodermi, which emerged in the Ordovician period 525 million years ago, and their habitats are located in a verti-

cal line of about 15 kilometers from sea level to 4000 meters above sea level and 11000 meters depth [15]. They have adapted to spend their entire lives in water. They can absorb oxygen dissolved in water through their organs called gills. Fish heart is two-eyed and always contains dirty blood. Fish are the group with the most species of vertebrates. According to different evaluations, the number of fish species varies between 15000 and 32000. It is generally accepted that there are around 30000 fish species. In other words, fish make up about 45% of all vertebrates. The high number of fish species is seen as a result of millions of years of evolution, causing adaptation in fish living in regions with different characteristics of the aquatic environment. The high number of species is also seen as an advantage in using fish as experimental animals. Factors such as the ease of maintenance and production of fish, the convenience of supply, and the fact that production environments can be easily created according to the population have caused fish to be widely preferred as experimental animals. In addition, the ease of application due to the water solubility of the drugs and chemicals to be used in the experiment is one of the reasons why they are preferred as experimental animals. The first legislation in Turkey regarding the use of experimental animals was established in 2004 and is in line with the laws and regulations of the European Union. A study shows that 2,104,828 experimental animals were used for experimental and scientific purposes between 2008 and 2017 in Turkey. Fish constitute 30.6% of these animals [16]. After the legislation on the subject was created in Turkey, universities and public institutions quickly determined ethical committees and rules. Thus, a certain standard has been achieved thanks to control and permission procedures. At the end of the process, a definite improvement was achieved in animal rights and ethics.

3. Conclusions

The evolutionary position of fish and their aquatic life characteristics have caused them to be seen as ideal creatures in the study of both somatic and reproductive and molecular evolution. In addition to topics such as Embryology, Neurobiology, and Endocrinology, they are seen as an important part of research in the field of Biomedical. Fish are also useful as biomarkers of environmental contaminations. Fish are used to reveal the presence of many toxic chemicals and pollutants, as well as to reveal the history of the host response [17]. Another reason for the widespread use of fish all over the world is the belief that fish do not suffer during experiments. However, this argument is not valid today. The presence of nociceptors (pain receptors) has been demonstrated by research in fish [18]. Evidence that fish may suffer has been cited by European Union food safety authorities [19]. An independent panel of experts appointed by the British Royal Society for the Prevention of Cruelty to Animals in 1980 stated that all vertebrates suffer to varying degrees [20]. For this reason, as with other vertebrate animals, animal welfare and ethical rules must be followed and necessary permissions must be obtained in all experiments with fish. The importance of the research and whether to use animals in the research is a matter for the researcher to evaluate and decide. In the presence and safety of adequate in vitro techniques, of course, animals should not be used. In addition, scientific journals should include detailed methodological information in the articles they will publish. The aim should always be to avoid the use of animals or to reduce their numbers. If they are to be used, the rules must be followed. In biomedical research, if fish are to be used, a concept must be given to systematically evaluate the suitability of the tests [21]. It will be useful to get help from experts about the fish species and methodology to be used in the experiments.

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Received: 02/02/2022 *Accepted: 20/03/2022*

International Journal of Advances in Biomedical Engineering
Open Access Peer-reviewed Journal
ISSN: 2822-2237
www.ijabe.online
Volume:1, Number:2, Pages:(69-77)
Year:2022

Partial Thoracic Type Ectopia Cordis; a Case Report

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Abstract

Ectopia Cordis (EC) is defined as a congenital defect which babies are born with their hearts outside their bodies. Abnormally located hearth (partially or totally outside of the thorax) mostly causes accompanying congenital anomalies. Although treatment options are limited and mortality rate is relatively high, surgical intervention is one of the most common treatment approaches. This paper presents a case of thoracic ectopia cordis with good outcome and its surgical intervention.

Keywords: Ectopia Cordis; Surgery; Case; Intervention

1. Introduction

Ectopia Cordis (EC) is defined as a congenital defect in which the heart is outside the thoracic cavity. This condition, which can be partially or completely, is called the Pentalogy of Cantrell together with other accompanying anomalies [1]. Based on the location of the heart, it is classified as cervical, cervicothoracic, thoracic, abdominal, and thoracoabdominal [2]. Previous research has established that it is more common in males and has an estimated prevalence of 5 to 8 per million live births [3]. Although the treatment is primarily surgical, the timing varies depending on the accompanying congenital anomalies. This paper discusses the case of thoracic ectopia cordis with good outcome and its surgical intervention.

2. Case Presentation

The case of a male infant, delivered by a normal vaginal route at 37 weeks of gestation was referred to our hospital with the diagnosis of ectopia cordis. The baby was the second living birth from the 4th pregnancy of a 21-year-old mother. It was stated that the mother had 2 abortions of unknown cause and had a healthy 1-year-old son. The parents were first cousins and no prenatal follow-up was performed. The newborn had an Apgar score of 5 and 6 in the 1st and 5th minutes, respectively. The newborn measured 50 cm and weighed 2,900 g, with a head circumference of 35cm. On examination, it was observed that there was no lower part of the sternum in the thorax region, and the apex of the heart was outside (Figure 1).

The patient's thoracic defect was covered with a sterile 3M drape. No additional anomaly was detected in the transthoracic echocardiography of the patient. Thorax tomography revealed a defect of approximately 2 cm in the anterior thoracic wall and a herniated heart apex on the skin from this defect, and it was stated that the sternum was agenetic (Figure 2).

As a result of a joint meeting with the cardiovascular surgery and plastic surgery departments, it was planned to operate the patient gradually at the most appropriate time. The patient underwent repair surgery of the chest wall On the 30th day of hospitalization. It was observed that there were skin adhesions due to epithelialization developing from the periphery where the heart apex was covered with granulation tissue. The granulation tissue on the myocardium without pericardium was scraped. Alloplastic material polytetrafluoroethylene (PTFE) [4][5].5x4 cm defect size was prepared by cardiovascular surgery and sutured to the deep fascia by controlling ventricular pressure. Pectoralis muscle medial was reached by progressing laterally from the border formed by dissection between the pericardium and the surrounding tissue. In the case without sternum and costochondral junctions, dissection was performed over the pectoralis muscle fascia until it reached the anterior axillary area. The perforators from the serratus and lattisimus dorsi muscle to the skin were preserved. After the medialization of the flaps and fixation sutures to the underlying pectoral muscle fascia, subcutaneous and skin suturing

Figure 1: Thoracic type ectopia cordis

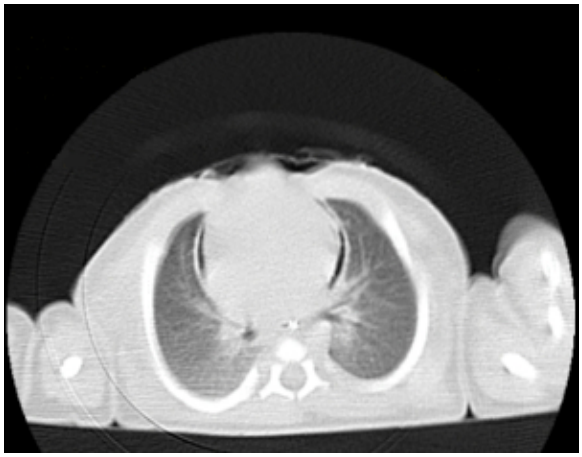

Figure 2: Chest CT findings.

was performed from the sternal notch localization to the umbilicus inferior. In the follow-up of the patient, single z-plasty was performed on the umbilicus for the

midline skin separation due to the compression of the PTFE alloplastic material on the skin. In the first operation for skin tension, the flaps that developed a delay procedure were transformed into bipediculated flaps with incisions made from the anterior axillary line, and the defect area was closed (Figure 3).

Figure 3: Postoperative view of EC

Thorax reconstruction was planned at a later period. The patient's paradoxical breathing was observed in the postoperative period. Current respiratory distress was attributed to agenesis of the sternum. The patient was discharged on the postnatal 117th day with recommendations. . Informed consent was obtained from the legally authorized representative for publication of this case report and any accompanying images.

3. Discussion

Although EC is rare, it is one of the anomalies that require urgent intervention in the neonatal period since the heart is outside. Its etiology is uncertain, but it is thought that the developmental defects of the sternum and thorax may be related to the embryonic period. Hypotheses regarding the etiology involve midline junction defect and primary descent disorder of the lateral body folds, midline junction defect due to early rupture of the chorion and/or yolk sac, or amniotic band syndrome [4][6]. It may also be associated with some chromosomal disorders such as Trisomy 18 and Turner syndrome [7]. Although chromosome analysis was sent

from the case, it was not evaluated as syndromic based on appearance and physical examination findings. Waiting for the result of chromosome analysis, the array is planned when necessary. EC is classified into 5 groups according to the location of the heart outside the chest. In the cervical type, the heart is located in front of the neck and there is no defect in the sternum. In the thoracocervical type, the heart is located in the cervical region, but there is an opening in the upper part of the sternum. In the thoracic type, the heart is partially or completely outside the thoracic cavity with the absence of the sternum or a wide cleft. In the thoracoabdominal and abdominal type, also called Cantrell's syndrome, the heart emerges from the abdominal cavity through a defect in the diaphragm [8]. The most common type is thoracic and abdominal type, accounting for 90% of known cases [9]. The cervical type is the most severe form and usually results in intrauterine death[10]. According to Smith, it was shown that restricted thoracoabdominal type EC has better results than cases with complete EC [11]. Complications such as heart failure, tamponade, cardiac rupture, endocarditis, and sudden death have been described in patients with EC [10]. However, it can be seen in a single cardiac defect or severe congenital cardiac malformations and affects the prognosis. However, other midline defects such as cranial cleft, cleft palate lip, hypoplastic lungs, diaphragmatic hernias can often accompany [12]. The fact that the heart is outside the thoracic cavity causes paradoxical movements of the lungs, and recurrent infection and hypoxemia are considered the main causes of death due to heart failure [10, 13]. The case had thoracic type EC with sternum agenesis. Only the apex of the heart protruded through the defect. The heart was not covered by the pericardium and was not accompanied by any other midline defect. The case had partial thoracic type EC and the prognosis was evaluated as better. Although paradoxical respiration was observed from time to time, recurrent lung infections did not develop. The absence of congenital heart defect with the partial type defect was evaluated as the reason for the better outcome. Diagnosis can be made very easily with ultrasonography in the prenatal period. If termination is not considered, clinical course and additional anomalies can be determined by MRI and fetal echocardiography [10]. Since the case did not have prenatal follow-ups, the diagnosis was made after birth, and tests were performed in terms of additional anomalies. The treatment of EC is primarily surgical repair. However, the timing of surgery varies according to the type of defect and additional anomalies. A multistage repair is the most common approach for surgical repair depending on the external condition and malposition of the heart. Recently, the multi-step surgical repair strategy is enclosed covering the heart with soft tissue, lowering the heart into the thoracic cavity, repairing additional cardiac defects, if any, reconstruction of the chest wall[14]. Due to the small defect of the case, the defect was first covered with a polytetrafluoroethylene (PTFE) membrane. In the next surgical application, tissue transfer was performed with a skin graft. Thoracic reconstruction was left for a later time.

4. Conclusion

Although EC is rare and the probability of survival is low, accompanying anomalies and the location of the defect affect the prognosis. The reason for the good prognosis in our case was evaluated as the small defect and the absence of accompanying anomalies. Besides, a multidisciplinary approach, including obstetricians, neonatal specialists, pediatric cardiologists, cardiac surgeons, and plastic surgeons, increases the chances of survival.

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Received: 19/03/2022 *Accepted: 25/04/2022*

International Journal of Advances in Biomedical Engineering
Open Access Peer-reviewed Journal
ISSN: 2822-2237
www.ijabe.online
Volume:1, Number:2, Pages:(78-86)
Year:2022

Spectral Characteristics of Intestinal Sounds

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Abstract

In today's modern medical practice, many imaging techniques are used for diagnosis or treatment. Some of these methods directly and some indirectly provide information about the target organ or region. At that point, it would be possible to accept that the acquisition of information about the internal parts of the body may be critical for diagnosis. In addition to the capabilities of medical imaging techniques, acoustic monitoring is also accepted as one of the supportive medical approaches today. Accordingly, thanks to the increased processing power of computers and developed algorithms, the analysis of sounds obtained from the heart, lungs and abdomen has become more detailed and accurate day by day. In this study, an acoustic instrument was developed and sounds were collected from the abdomen with the help of this device. Acoustic data on intestinal activity were obtained by filtering the collected sounds on the computer. The spectral characteristic of this data is revealed with various features for further diagnostic studies.

Keywords: Acoustic; Intestinal; Spectral; Features

1. Introduction

It has been accepted today that bowel sounds carry data about the functioning of internal organs, just like heart or liver sounds [1]. Accordingly, it would be possible to accept that the sounds of the intestines originate from vital processes for humans and that the acoustic characteristic will change in case of an abnormality. Extracting the numerical characteristic of the functionality of the intestines will be useful in many medical practices today, from understanding the time of feeding in the postoperative period to the early diagnosis of a wide range of intestinal disorders. However, today, brief clinical auscultation is most likely preferred for diagnosis rather than computer aided diagnosis and classification systems [2, 3]. Rapidly developing computing technologies can produce fast solutions to many diagnostic problems that require complex numerical solutions [4, 5]. Utilization of computer-assisted automatic analysis and diagnostic systems in cooperation with the conventional auscultation approach would improve the medical practice [6]. Accordingly, intestinal sounds originating from bowel activity are captured and analysed in this study as a starting point. Spectral characteristics of the captured acoustic data is revealed for forming a basis for further diagnosis and classification studies.

2. Methodology

2.1. Acquisition of Gastrointestinal Sounds

a non-invasive acoustic instrument was implemented for the acquisition of gastrointestinal sounds from subjects. The instrument is designed to record acoustic activity from the abdomen of the patient so that further analysis can be completed at digital environment. Acoustic data, including bowel sounds, are collected from the abdomen via a diaphragm and sent to the electret microphone. In this study, mentioned acoustic data collection is achieved via a 3M Littmann, Classic II S.E model stethoscope head. Which has a tunable diaphragm (with a diameter of 4.44 cm) and open bell that allows device collect sound-waves with high sensitivity. Before recording raw acoustic data a pre-amplication is applied to analog signal for adjusting signal to noise ratio to an optimum rate. Low-noise and wide-spectrum pre-amplification is achieved by a ”jfet” input type ”op-amp”. Preferred integrated circuit for the purpose is TL082 instrumentation operational amplifier which provides high reliability and efficiency. It is known that the sound waves to be collected from the abdominal region also include other sounds coming from the heart, lungs and outside [7]. In previous studies, the recommended spectral range for gastrointestinal activity to be separated from these noise sources is 200-500 Hz [8]. This filtering operation is applied to raw digital data after recording. Additionally tension of the diaphragm is tuned for intestinal acoustic waves which means diaphragm is also serving as a mechanical pre-filter that eliminating irrelevant data out of the focused frequency range.

Intestinal sound recordings were made with a T60 brand original 8gb voice recorder. Raw data is recorded as dual channels with a sampling frequency of 44100 and a bit rate of 1536 Kbps. Average recording length is 97.26 seconds. A total of 20 subjects are participated. Age and body mass averages are given in Table 1.

Table 1: Average values of age and body mass index of subjects

Age	**Body Mass Index**
34.5 ± 10.8	26.3 ± 3.2

2.2. Segmentation Stage

Recorded audio data is likely to contain various noises and distortions along with characteristic sounds associated with the intestinal activity. These include friction sounds caused by the movements of the patient, unusual sounds transmitted from the environment through the patient's body, and electronic noise caused by electronic interference. Additionally, patient's respiratory sounds, sound of blood flow, and heartbeat can be seen scattered across a wide frequency spectrum of the raw data. In this study it was aimed to extract spectral features characterizing the bowel activity. Accordingly bowel activity regions are segmented empirically by two experts for further feature extraction process. A total of 40 region is segmented from different subjects.

2.3. Feature Extraction

2.3.1. Spectral Centroid

This feature extracted for measuring the location of the center of mass of the spectrum. It is calculated by:

$$Centroid = \frac{\sum_{k=b_1}^{b_2} f_k s_k}{\sum_{k=b_1}^{b_2} s_k} \tag{1}$$

where f_k and s_k are indicating frequency corresponding to bin k and spectral value at bin k. b1 and b2 are denotes band edges [9].

2.3.2. Spectral Entropy

Spectral entropy can be defined as spectral power distribution of a signal. It is one of the widely used features for biomedical signal processing [10]. If Fourier

transform of signal $x(n)$ is $X(m)$ then power spectrum would be calculated by:

$$S(m) = |X(m)|^2 \tag{2}$$

Accordingly, formulation of the probability distribution P(m) is:

$$P(m) = \frac{S(m)}{\sum_i S(i)} \tag{3}$$

where the spectral entropy is:

$$H = -\sum_{m=1}^{N} P(m) log_2 P(m) \tag{4}$$

Finally, the normalization is calculated by:

$$H_n = -\frac{\sum_{m=1}^{N} P(m) log_2 P(m)}{log_2 N} \tag{5}$$

Here, N is standing for the the total frequency points and $log_2 N$ represents the maximal spectral entropy of white noise.

2.3.3. Spectral Flux

It would be possible to define spectral flux as change in consecutive spectrums. [11] which is formulated by:

$$flux(t) = \left(\sum_{k=b_1}^{b_2} |s_k(t - s_k(t-1)|^p \right)^{\frac{1}{p}} \tag{6}$$

Where k, b1 and b2 are value of spectrum at bin k, and band edges respectively. It should be noted that P indicates the norm type which would be valued as double or single.

2.3.4. Energy

In the study, the energy is accepted as area under the squared magnitude of the signal.

2.3.5. Zero Crossing Rate

The zero crossing rate (ZCR) is accepted change rate of the signal from positive to negative.[12].

2.3.6. Spectral Rolloff

It is accepted as frequency value where the 85% of the signal distribution is located.[13].

3. Results

A total of 6 features are extracted from 40 intestinal activity region. Cluster centers of features and standard deviations are given in Table 2.

Table 2: Calculated spectral features of the intestinal activity regions on recorded audio data.

	Cluster Centroid	**Standard Deviation**	**Maximum Value**	**Minimum Value**
Spectral Centroid	0.028722	0.008823	0.069692	0.020148
Spectral Entropy	0.000530	0.001310	0.008243	0.000011
Spectral Flux	2.55164E-26	2.12718E-26	7.47678E-26	2.64092E-27
Energy	0.029381	0.022451	0.100320	0.006531
Zero Crossing Rate	0.015856	0.000758	0.018110	0.014869
Spectral Roll-off	0.014545	0.001023	0.017007	0.012634

4. Discussion and Conclusions

Many studies in the literature show that with the evaluation of acoustic data, it is possible to make accurate classifications about the abnormality in the abdominal region [14]. It would be possible to conclude that, objective assessment of activity would contribute to daily surgical practice in evaluating intestinal motility that may develop in the postoperative period, determining the feeding time, and diagnosing ileus. In this study, as a first step in the automatic diagnosis of intestinal activity, the spectral features characterizing the activity were extracted from the sound recordings and presented numerically. Presented results would be helpful for further studies on automated or semi-automated decision making systems.

Competing interests

The authors declare that they have no conflict of interests.

Ethics approval and consent to participate

The authors declare that this study does not contain any personal information that could lead to the identification of the patients and Informed consent was obtained from all participants. The work described has been carried out in accordance with the ethical approval of the Cukurova University Faculty of Medicine, Non-Interventional Clinical Research Ethics Committee.

Consent for publication

All authors read and approved the manuscript.

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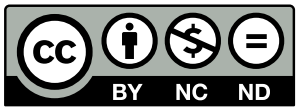

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Received: 07/04/2022 *Accepted: 29/04/2022*

International Journal of Advances in Biomedical Engineering
Open Access Peer-reviewed Journal
ISSN: 2822-2237
www.ijabe.online
Volume:1, Number:2, Pages:(87-93)
Year:2022

Mini Review: Nature-Inspired Algorithms in Tomography

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Abstract

Tomography is simply generation of cross-sectional images of body via any kind of penetrating wave. Today, tomography is one of the most popular medical imaging modalities that is mostly preferred for monitoring body internals to search for any kind of abnormalities. In this article, it is aimed to review some of the most successful implementations of nature-inspired algorithms used in the development of tomography technology.

Keywords: Tomography; Intelligent; Nature-inspired; Technology

1. Introduction

Tomography is one of the medical imaging modalities which is widely used for monitoring body internals by cross-sectional images. The word tomography word originating from imaging by sections. It was first introduced to the public in 1972 [1, 2]. Devices used for generating tomography images are called tomograph and images generated by these devices are called tomograms. A tomography required to be able to generate waveforms that can penetrate through body. A rotating axis moves the source of these waves during the imaging. Whereby a 2 dimensional cross-section image of body is generated with each step. One of the oldest and most popular type of tomography is x-ray tomography where a x-ray source is utilized for imaging. This non-invasive modality gives doctors ability to scan body internals for abnormal regions. It has found widespread use since it was first announced to the public. There are approximately 70 million recorded examinations in 2007 in the US alone [3]. With the widespread use of tomography technology, diagnostic problems that can be optimized have also increased. Rapidly evolving computing technologies have increased the diagnostic and imaging potential of tomography, as well as medical diagnostic capacity. At this point, mechanisms inspired by nature have been used to solve many problems that may be challenging for traditional approaches. In this article some of the most successful implementations of nature-inspired algorithms used in the development of tomography technology are reviewed.

2. Use of Nature-Inspired Algorithms in Tomography

Biomimicry is an innovative approach focused on adapting nature's mechanisms into high-tech problems. Similarly, nature-inspired algorithms have been successfully applied in the solution of many biomedical problems. The optimization of problems with nature-inspired algorithms has also increased the evolutionary acceleration of tomography technology. Study of Rattan et al. may be given as an interesting example which they have utilized BAT algorithm for optimizing segmentation problem of tomography images [4]. They have utilized a series of algorithm combinations for automated detection of lung nodules. The BAT algorithm is inspired by the bats' perception of their environment. Accordingly, the bats' echolocation-based sensing abilities were simplified and used for optimization [5]. Similarly Filho et al. have presented a study in 2017, focused on lung nodule diagnosis in computed tomography (CT). They have utilized a combination of genetic algorithm, phylogenetic diversity and support vector machines. They have utilized genetic algorithm for selecting the best individuals to generate the model that will be used in the classification [6]. Genetic algorithm is also a nature inspired meta-heuristic algorithm that allows us to find solutions for complex problems by mimicking the evolution elements of nature such as selection, mutation and reproduction [7]. Moreover they have utilized phylogenetic trees as texture descriptors.

This is also a nature inspired approach. Phylogenetic trees are used in Biology for showing the evolutionary relationships [8]. Resolution is one of the critical factors that directly affects the medical efficiency of the CT. Higher resolution means more accurate detection of abnormal regions. It is possible to enhance resolution by hardware improvements like sensor improvements [9]. However there are many studies that aims to refine the reconstruction of CT images and enhancing the images. As an example, Yu et al. proposed a deep neural network based approach as a Super-resolution (SR) technique. They have managed to take a single image as input and produce SR images by utilizing deep convolutional neural networks [9].

Single photon emission is one of the types of computed tomography. Single photon emission computed tomography (SPECT) uses gamma rays and can provide 3D images of body internals [10]. Samadiani and Moameri proposed a nature inspired mechanism for diagnosis of coronary artery disease from SPECT heart images [10]. They have innovatively utilized genetic algorithm for selecting best features. Moreover they have also implemented Cuckoo Search (CS) algorithm for search space reduction. It is one of the population based meta-heuristic algorithms [11].

Automated segmentation of CT images is also one of the challenges of latest studies. Dorgham and friends have presented a paper that tackles such problem. Their innovative approach is based on monarch butterfly optimization (MBO) algorithm. They have utilized that algorithm for finding optimal threshold for segmentation. MBO algorithm is inspired from the transmigration behavior of monarch butterflies which increases the probability of finding the optimal threshold [12]. Similarly Pleszczynski and friends inspired from animal behaviour for reconstruction of incomplete tomography data in their study [13]. They have implemented polar bear optimization algorithm which is based on hunting characteristics of polar bears [14].

Genetic algorithm is one of the widely used nature inspired algorithms for enhancing tomography technology. Mishra and friends implemented a self-guided genetic algorithm as a reconstruction algorithm for limited view or sparse data [15]. A self-guided Genetic Algorithm is kind of a Estimation of Distribution Algorithms (EDAs) that use the probabilistic model to sample new solutions without the help of conventional genetic operators [16].

3. Conclusion

When the development process of tomography is examined, it is seen that the developments in information processing technologies play a serious role on tomography technology. The rapidly accelerating computing power makes it possible to adapt more mechanisms from nature to solving numerical problems. The studies examined in this article show that the ways in which nature evaluates complex problems within its unique system have the potential to be a serious source of inspiration for human beings. In addition, the non-invasive three-dimensional visual data presented by this new imaging technique is a source for completely new and challenging problems for scientists to explore. This new data source, which has the potential to carry critical information for human life, also creates diagnostic and enhancement problems that are increasingly difficult to solve. The reviewed articles show that solutions inspired by nature play a role in increasing the depth of data that tomography can offer and in making the tomography technique much more intelligent, flexible and adaptive than it is.

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