Indian Journal of Anatomy

Indexing Information: Index Copernicus, Poland, Google Scholar, ProQuest, USA, Genamics JournalSeek.

Printed at Saujanya Printing Press, D-47, Okhla Industrial Area Phase-1, New Delhi - 20

Red Flower Publication Pvt. Ltd.
48/41-42 DSIDC, Pocket-II, Mayur Vihar Phase-I
Delhi - 110 091(India)
Phone: 91-11-22754205, 45796900, Fax: 91-11-22754205
E-mail: redflowerppl@vsnl.net
Web:www.rfppl.co.in

The Indian Journal of Anatomy is a quarterly print and online journal of the **Red Flower Publication Pvt. Ltd.** publishes original and peer-reviewed articles, for the dissemination of anatomical knowledge with clinical, surgical and imaging guidance. Includes articles of history, reviews and biographies, locomotors, splachnology, neuroanatomy, imaging anatomy, anatomical variations, anatomical techniques, education and pedagogy in anatomy, Human Anatomy, Veterinary Anatomy, Embryology, Gross Anatomy (Macroscopic), Microscopic Anatomy (Histology, Cytology), Plant Anatomy (Phytotomy), Comparative Anatomy, editorials, letters to the editor, and case reports. Articles of veterinary anatomy, comparative and other morphological sciences are accepted.

Readership: Anatomical specialties, veterinarian, embryologists.

Indexing Information: Index Copernicus, Poland, Google Scholar, ProQuest, USA, Genamics JournalSeek.

Subscription Information

India

Individual	
1 Year	Rs. 500
Life Subscription (Valid for 10 Years)	Rs. 3000
Institutional (1 Year)	Rs. 3200

Rest of the World

Individual (1 Year)	USD100
Institutional (1 Year)	USD260

PAYMENT METHOD

By Cheque/Demand Draft:

Cheque should be in the name of **Red Flower Publication Pvt. Ltd.** payable at Delhi.

By Bank Transfer/TT:

Bank name: Bank of India

Swift Code: BKIDINBBDOS

Account Name: Red Flower Publication Pvt. Ltd.

Account Number: 604320110000467

Branch: Mayur Vihar Phase-I

Delhi - 110 091 (India)

Send All Orders to: **Red Flower Publication Pvt. Ltd.,** 48/41-42, DSIDC, Pocket-II, Mayur Vihar Phase-I, Delhi - 110 091, India, Phone: 91-11-22754205, Fax: 91-11-22754205, E-mail: redflowerppl@vsnl.net, Website: www.rfppl.co.in

Indian Journal of Anatomy

October - December 2014
Volume 3 Number 4

Contents

Original articles

Riview articles

Revised Rates for 2014 (Institutional)

Title	Freequency	Rate (Rs): India	Rate ($):ROW
Dermatology International	2	2500	280
Gastroenterology International	2	3500	360
Indian Journal of Agriculture Business	2	4500	300
Indian Journal of Anatomy	2	3200	260
Indian Journal of Ancient Medicine and Yoga	4	6600	330
Indian Journal of Anesthesia and Analgesia	2	4000	600
Indian Journal of Anthropology	2	8000	500
Indian Journal of Applied Physics	2	3500	400
Indian Journal of Biology	2	1500	170
Indian Journal of Cancer Education and Research	2	4500	500
Indian Journal of Communicable Diseases	2	1000	58
Indian Journal of Dental Education	4	3200	288
Indian Journal of Forensic Medicine and Pathology	4	12500	576
Indian Journal of Forensic Odontology	4	3200	288
Indian Journal of Genetics and Molecular Research	2	5000	262
Indian Journal of Law and Human Behavior	2	5000	500
Indian Journal of Library and Information Science	3	7500	600
Indian Journal of Maternal-Fetal & Neonatal Medicine	2	4500	400
Indian Journal of Mathematics and Statistics	2	3000	200
Indian Journal of Medical & Health Sciences	2	1800	120
Indian Journal of Obstetrics and Gynecology	2	2000	200
Indian Journal of Pathology: Research and Practice	2	3000	915
Indian Journal of Plant and Soil	2	5000	1700
Indian Journal of Preventive Medicine	2	3200	270
Indian Journal of Reproductive Science and Medicine	4	3000	180
Indian Journal of Scientific Computing and Engineering	2	3300	280
Indian Journal of Surgical Nursing	3	1800	70
Indian Journal of Trauma & Emergency Pediatrics	4	6500	302
International Journal of Agricultural & Forest Meteorology	2	8000	800
International Journal of Food, Nutrition & Dietetics	2	3200	900
International Journal of History	2	6000	500
International Journal of Neurology and Neurosurgery	2	7500	276
International Journal of Political Science	2	5000	400
International Journal of Practical Nursing	3	1500	70
International Physiology	2	4000	240
Journal of Animal Feed Science and Technology	2	3500	280
Journal of Cardiovascular Medicine and Surgery	2	5500	238
Journal of Orthopaedic Education	2	2500	190
Journal of Pharmaceutical and Medicinal Chemistry	2	3000	350
Journal of Psychiatric Nursing	3	1800	70
Journal of Social Welfare and Management	4	6600	276
Meat Science International	2	5000	500
Microbiology and Related Research	2	3800	150
New Indian Journal of Surgery	4	6500	360
Ophthalmology and Allied Sciences	2	3000	150
Otolaryngology International	2	2000	300
Pediatric Education and Research	4	3200	150
Physiotherapy and Occupational Therapy Journal	4	7000	360
Urology, Nephrology and Andrology International	2	2200	350

Terms of Supply:

1. Advance payment required by Demand Draft payable to Red Flower Publicaion Pvt. Ltd. payable at Delhi.
2. Cancellation not allowed except for duplicate payment.
3. Agents allowed 10% discount.
4. Claim must be made within six months from issue date.

Order from

Red Flower Publication Pvt. Ltd., 48/41-42, DSIDC, Pocket-II, Mayur Vihar Phase-I, Delhi - 110 091 (India), Tel: 91-11-22754205, 45796900, Fax: 91-11-22754205. E-mail: redflowerppl@vsnl.net, redflowerppl@gmail.com, Website: www.rfppl.co.in

Original Article

Indian Journal of Anatomy
Volume 3 Number 4, October - December 2014

'Body Donation Awareness' - The only solution for the Scarcity of Cadavers in Medical Education in India

D.K. Sharma*, Mrithunjay Rathore, A.U. Siddiqui*****

Abstract

'Body donation' is the donation of the whole body after death for medical research and education. Medical institutes use cadavers to teach anatomy by corpse dissection but cadavers are now a scarcity with mushrooming of medical institutions in our country and it is also not deniable that opening new medical institutes is must to balance the doctor-population ratio. Presently it is a daunting task to make students well-versed with the anatomy due to lack of cadavers and so the students are being taught by software, charts and models. Under Anatomy Act of India, the unclaimed bodies have limitations and mostly they are not useful; and the practice of burial or cremation of corpse is a trend in India. So the only source of cadavers is the donated bodies but there is paucity of awareness regarding the gracious and ideal act of body donation. Present work simply tried to assess the views, thoughts and awareness of the public of various field about the concept of body donation by a questionnaire; analysed and concluded with the ideas that (i) the books and computer cannot replicate the hands on method of teaching human anatomy and replace the human body dissection (ii) availability of cadavers is must for delivering excellence in teaching anatomy and conducting researches in the field of medical science (iii) 'Body Donation Awareness' by public campaigns, exhibitions etc. in large scale is the uttermost necessity for lacking cadavers and so the encouraging & motivating body donation by bringing 'body donation awareness' is the only solution for the scarcity of cadavers in Medical Education in India and (iv) in the spring of each year, the Institute should organize a memorial service to honor their donors from the previous year. Family members and friends of the donor should be invited.

Keywords: Body donation, Dissection, Anatomy Act, Campaign, Replicate

Introduction

Even in death do we serve life' Inscription on a communal grave is dedicated to body donors. Body donation is useful for medical education in understanding the human body and for advancing researches in medical science. Medical institutes use embalmed bodies to teach anatomy to medical students by cadaveric dissection and the Anatomy is a branch of science which deals with the macroscopic and microscopic structures of the body. Human cadavers for the purpose of study are a scarcity with mushrooming of medical institutions in this country. Presently, it has become a daunting task for the medical institutes to make their students well-versed with the anatomy subjects and the reason is lack of donated bodies and cadavers and students are being taught on specially designed software and artificially prepared models. On one side the unclaimed bodies obtained from the police have some limitation and restriction and mostly they are not useful and on the other side the practice of burial or cremation of dead bodies as religious tradition in India and the lack of awareness regarding the gracious and ideal act of body donation.

Author's Affiliation: *Additional Professor, **Assistant Professor, Department of Anatomy, All India Institute of Medical Sciences, Raipur, Chhattisgarh.

Corresponding Author: Dr. D.K. Sharma, Additional Professor and Head, Department of Anatomy, All India Institute of Medical Sciences (AIIMS), Raipur, Chhattisgarh-492099

Email: dhyanesh.sharma@gmail.com

Material and Methods

We underwent an analysis by a questionnaire (Figure 1) designed to assess views and thoughts regarding body donation among the population of Raipur City including the lawyers, engineers, teachers, farmers and others. In total 2500 people of age group 18-65 years, age, sex, religion, awareness about body donation & its significance, their positive and negative attitudes towards body donation and its religious aspect, willingness to donate body, other concepts and suggestion were recorded. To bring awareness among people about the gracious act of 'body donation' we organized a symposium and an exhibition (Figure 2). General public from all fields, Police department and News-media were invited. The results of the questionnaire were analyzed and presented.

Results

After analysis of questionnaire among 2500 people we found that 18% people were unaware about the body donation and its significance. They did also not know that cadavers or donated bodies are used for the medical education and research. 82% people knew about body donation and 56% person did not believe in body donation and most of them have reason behind it their religious tradition. 22% thought that donated bodies are misused and teaching Anatomy and research in medical science can be done without cadavers. 15% expressed that they can think about 'Body Donation' in future and 52% said that medical professionals should explain, aware and educate the general public about the importance of this gracious and ideal act of 'Body Donation'. Only 4% showed their willingness for body donation and 2% had already registered their names for body donation. Majority had opinion that body donation is a noble act. Some put suggestions like in the spring of each year, the Institute should organize a memorial service to honor their donors from the previous year and invite family members and friends of the donor. After this symposium, exhibition and questionnaire assessment, in next 3 months more than 80 people have pledged for body donation and we have received 4 death bodies on donation.

Discussion

We all are aware that for the last few years the human cadavers for the purpose of study are a scarcity with mushrooming of medical institutions in this country. We know that opening new medical institutes is also must to balance the doctor population ratio. Medical ethics says during study a single body has to be shared among 10 students only but in present situation in most of the institutions there are 1 body for 25 students. Even only 1 body for the whole batch of 100 or 150 students are also not uncommon. Our Institute All India Institute of Medical Sciences Raipur is also facing this problem of scarcity of cadavers and last year we completed our dissection with only 2 cadavers for 50 students and this year also we have started dissection with only 2 cadavers for 100 students.

In India there are two sources to get cadavers in the medical institutes (i) unclaimed bodies by the police and (ii) body donation. There are 4 main reasons for the scarcity of cadavers (i) the unclaimed bodies provided by the police having some restriction & limitation and mostly they are not useful (ii) religious traditions of burial and cremation of dead bodies (iii) lack of awareness of body donation and (iv) increasing number of medical institutes. We experienced 2 things (i) the unclaimed bodies are mainly supplied to Govt. Medical Colleges by the police and (ii) there is a general unawareness and misconception among the people about the gracious, ideal and moral act of body donation.

Actually Police has to distribute the unclaimed bodies on priority based on request and requirement of bodies by institutes both government and non-government according to Anatomical Act. The 'Body Donation Awareness' is limited to some extent so bringing awareness for body donation in large scale amongst people is still uttermost necessity. Although some NGOs (Yug Dadhichi in Uttar Pradesh, Badhte Kadam and Manawta in Chhattisgarh and Mohan Foundation in AP etc.) have realised and come front to make solution but the awareness of voluntary body donation in large scale among people can only be brought and possible by medical professionals and media by different means like public campaigns, exhibitions etc.

In India, the Anatomy Act came into enactment in the year 1949 which has been adopted by all the states. It provides for the collection of dead bodies for teaching purpose, only if death occurs in state hospital or in a public place within the prescribed zone of medical institutions, provided the police have declared a lapse of 48 hours that there are no claimants for the body and it could be used for the medical purpose. Notably, the Anatomy Act enacted by various states provides for the supply of unclaimed bodies to medical and teaching institutions for the

purpose of anatomical examination & dissection, researches and other similar purposes.

The other countries have differing regulations surrounding the donation of the body or body parts. Body donation in the UK is governed by the Human Tissue Authority (HTA) under the auspices of the Human Tissue Act 2004. Under the Human Tissue Act, written consent must be given prior to death; consent cannot be given by anyone else after death. Only the legal next-of-kin of the deceased can provide the necessary consent for donation if the donor did not provide it to the specific accepting program prior to death. The American Association of Tissue Banks (AATB) and American Medical Education and Research Association (AMERA) provide accreditation to the whole body donor organizations and university anatomical programs etc.

Body donation is a gracious and ideal act and it has been practicing since ancient time for the welfare of mankind and country. Shankaracharyas the Hindu Saints firmly believe in the concept of 'body and organ donation' and say 'Idam sharirum paropkarum' i.e. the body is for the use of others and the death is not the end, it is the beginning. Maharshi Dadhichi or Dadhincha is an important character in Hindu mythology, revered amongst the greatest of sages and portrayed as an example that no sacrifice is too great when the result is good and beneficial for the world. His bones are used as a symbol on India's highest award for gallantry "Param Vir Chakra" as "Vajra". He is credited with giving up his life in order to allow the Devtas or Suras to use his bones to make weapons to defeat the Danvas or Asuras.

In India the trend of donating body became quite prevalent in the year 2005 in Agra city by an NGO with the start of 'Yug Dadhichi Program' where more than 500 people have registered themselves for donating their bodies. This organisation in Taj city is still active and last year on12th May 2012 a Campaign for body donation was done to promote the donation of human bodies for educational research. In case of body donation program the relatives of the deceased donate body to the medical institute according to the dead person wishes. Nobody was forced to donate body. It was left to one's own decision which is voluntary. However, there is no age barrier for body donation but people above the age of 18 can enroll themselves. Any person wishing to donate their body may require but not always making prior arrangements with the institute or body donation program before death. Individuals may request a consent form and will be supplied information about policies and procedures that will take place after the potential donor is deceased.

On the eve of 'Organ Donation Day' 2011 in India, Dadhichi Mission in association with R. D. Gardi Medical College organized an event on November 28th at Ujjain to spread awareness of organ donation among the people of India. The event marked the first-time celebration of 'Organ Donation Day' in Central India. Eight members of a Bhatia family, all senior citizens, honored after pledging to donate their bodies for medical education and research at Government Medical College and Hospital, in Chandigarh. Freedom fighter Captain Lakshmi Sahgal's body was taken to the GSVM medical college in Kanpur for research who passed away at the age of 97. Her daughter said, "As per her last wish, we have donated her eyes and her body for medical research and handed over to the Ganesh Shankar Vidyarthi Memorial Medical College". Sons donated their Father Late Sangram Singh Hiran's Corpse to fulfill his will on January 22, 2013 to Medical College. Actor Parthiban Appreciated 'Voluntary Body Donation Program' in January 9, 2011 in Chennai by Mr. S. Ashok Kumar and Mrs. Chitra Ashok Kumar, Who are giving their service in creating awareness in voluntary body donation. They have jointly enrolled 150 persons for whole body donation after their demises in Anatomy Department, Government Hospital in last 2 years. They both are 1st and 2nd receivers of Identity card for this program respectively. Earlier body donation for medical science was a trickle but after communist leader Jyoti Basu's and Jana Sangh leader Nanaji Deshmukh bodies were donated to medical science, that trickle has turned into something of a tidal wave.

The decision to become a body donor is influenced by factors such as social awareness, cultural attitudes & perceptions of body donation, cultural attitudes and perceptions of death, religion, and perceptions of the body-mind relationship[1]. Studies indicate most donors are primarily driven by altruism and their desire to aid the advancement of medical knowledge and to be useful after death. Other reasons include helping future generations, expressing gratitude for life and good health or for the medical field, to avoid a funeral or to avoid waste[2]. The offering of financial incentives as a way to increase donor numbers or as an acknowledgement for donors is generally considered to detract from the act of donation and serve as a deterrent[3]. However, a US study showing a positive correlation between body donation numbers and funeral cover cost savings offered as compensation suggests that, in reality, the added incentive could be a persuasive factor for donors[4].

Anatomy teaching is undergoing major changes due to time constraints, scarcity of cadavers, rapid

advances in information technology and changes in the demands of the medical profession. In this changing scenario of medical education a continuous debate is on among the educators regarding usefulness and effectiveness of the conventional and newer teaching/learning methodologies. Analysis of literature available recommends that the superiority should not be to determine superiority of one methodology over another but to capitalise on the learning benefits offered by the different methods. The learner should be provided opportunity to use multiple resources[5].

Though in the era of this advanced technology and time of computer, LCD and availability of large number of books and teaching aids the teaching pattern has changed but the books and computer can't replicate the hands on method of teaching human anatomy and replace body dissection in anatomy. So availability of cadavers is must for delivering excellence in teaching and research in field of medicine. The medical professionals and media can play important role by public campaigns, exhibitions etc. Encouraging/motivating body donation and bringing awareness in people about it seem to be the only solution to fulfill scarcity of cadavers.

Fig 1: Showing the Questionnaire to assess views about Body Donation

Questionnaire to assess views about 'Body Donation'

- Age:
- Sex:
- Religion:
- Profession:
- Have you heard about 'Body Donation? Yes/No
- I know that "Body Donation is defined as the act of giving one's body after death for the medical research and education" Yes/No
- Have you heard about **Rishi Dadhichi** an important character in Hindu mythology, who is credited with giving up his life in order to allow the Devtas or Suras to use his bones to make weapons to defeat the Danvas or Asuras? Yes/No
- Do you know the significance of 'Body donation'? Yes/No
- Do you know the donated body is used for the medical education? Yes/No
- Do you know the donated body can be used for the research and other purposes? Yes/No
- Do you believe in ' Body Donation'? Yes/No
- I do not believe in 'Body Donation' due to my religious tradition. Yes/No
- I believe that donated bodies are misused. Yes/No
- I will bring awareness about 'Body Donation' among people. Yes/No
- I can think about 'Body Donation' for myself in future. Yes/No
- I am willing for 'Body Donation'. Yes/No
- Medical professionals should explain, aware and educate the general public about the importance of this gracious act of 'Body Donation'. Yes/No
- Teaching Anatomy and research in medical science can be done without cadavers. Yes/No
- Personal comments on the subject:

Anatomical donations are regarded as unselfish gifts to medical education and research. Donors and their families can be assured their contribution is appreciated and treated with the utmost respect. **It is strongly recommended that donor should discuss this decision with his/her family to better assist them with arrangements at the time of death.** Time is a factor and next of kin must be in a position to act immediately following death. It is also wise to inform physician, lawyer, and funeral director of your wishes. **At The Time of Death,** the Division of Anatomy should be contacted immediately. Although each **preregistered** donor is normally accepted, restrictions may include:

- Contagious disease (HIV, Hepatitis, TB, Creutzfeldt-Jakob disease, any hospital acquired disease including MRSA and Clostridium difficile, etc.)
- Extreme emaciation, obesity, or body contractures
- Severe trauma or open wounds (including certain recent surgeries)
- Ascites, edema, or septicemia
- Organs or parts removed at time of death, except eyes
- Current education or research programs are not in need of donors

In the spring of each year, students of Institute should organize a memorial service to honor their donors from the previous year. Family members and friends of the donor should be invited.

Fig 2: Showing the Banners and Posters displayed by the Department

BODY DONATION AWARENESS

Why cremation or burial after death when we can donate or gift it in allegiance to God, Country and Medical Science?

Donating your body after death to the Science or a Body farm?

Donating your eyes after death, then why not whole body?

Shri Shankaracharya believed in the concept of 'body donation' and said 'Idam sharirum paropkarum' i.e. the body is for the use of others and the death is not an end, it is the beginning.

Appeal by the Department of Anatomy, All India Institute of Medical Sciences (AIIMS), Raipur, C.G. India

Cadaveric dissection is the integral part of the anatomy curriculum of Medical Science and there is a strong need to popularize the message to common masses to donate their bodies after death for the teaching and research purposes. A person in his life can express his will for body donation in writing (Will form can be obtained from the Department of Anatomy) and can convince his next kith and kin about his / her pledging. The donor will be provided a 'Certificate of Honour' by the Institute. The dead body along with the death certificate should be transported within 6 hrs to the Department of Anatomy AIIMS Raipur. In case of delay in transporting, the body should be kept in mortuary or on ice slabs and if needed the Department of Anatomy AIIMS Raipur can provide a vehicle to transport the body within Chhattisgarh state.

Conclusion

Present work simply tried to assess the views, thoughts and awareness of the public of various field about the concept of body donation by a questionnaire; analysed and concluded with the ideas that (i) the books and computer cannot replicate the hands on method of teaching human anatomy and replace the human body dissection (ii) availability of cadavers is must for delivering excellence in teaching anatomy and conducting researches in the field of medical science (iii) 'Body Donation Awareness' by public campaigns, exhibitions etc. in large scale is the uttermost necessity for lacking cadavers and so the encouraging & motivating body donation by bringing 'body donation awareness' is the only solution for the scarcity of cadavers in Medical Education in India and (iv) in the spring of each year, the Institute should organize a memorial service to honor their donors from the previous year. Family members and friends of the donor should be invited.

References

1. Savulescu J. Death, Us and Our Bodies: Personal Reflections. *Journal of Medical Ethics*. 2003; 29(3): 127-130.
2. Bolt S, Venbrux E, Eisinga R, Kuks J B M, Veening J G, Gerrits P O. Motivation for body donation to science: More than an altruistic act. *Annals of Anatomy*. 2010; 192(2):70-74.
3. Ajita R, Singh I. Body Donation and Its Relevance in Anatomy Learning – A Review. *Journal of the Anatomical Society of India*. 2007; 56(1): 44-47.
4. Harrington D E, Sayre E A. Paying for Bodies, But Not for Organs. *Regulation*.2007; 29(4): 14-19.
5. Singh V, Kharab P. A paradigm shift from teaching to learning gross anatomy: meta-analysis of implications for instructional methods. *Journal of the Anatomical Society of India*. 2013;62(1):84-89.

Original Article

Indian Journal of Anatomy
Volume 3 Number 4, October - December 2014

Undergraduate Modified Teaching : Feedback

Col Sushil Kumar*, R.K. Zargar, Dope Santoshkumar A.*****

Abstract

The MCI issued the directives in 1997 resulting in compression of 1st MBBS curriculum into 1 year. It took both the teachers and students by surprise. The conscientious faculty felt committed to the cause of the students that demanded intense and speedy action. We deliberated to devise methods for improvement. Meetings were organised with representatives from each dissection table once a fortnight. The outcome of the interactions motivated us to modify the teaching methodology to meet the requirements. Thereafter, we got the efforts put in by us evaluated by the students. For this a questionnaire was given to the students after passing 1st MBBS examination. Data was compiled for three consecutive years. Students came up with suggestions and were forthright in pointing out the shortcomings of a particular teacher. Their views were taken sportingly and efforts made to improve and comply with some of the worthy suggestions.

Many issues concerning the effectiveness, fairness, and reliability of using student feedback as a method to improve teaching performance have been discussed

Keywords: Compression of 1st MBBS Curriculum; Modified teaching technology; Effectiveness of feedback.

Introduction

The directives issued in late nineties by the MCI to compress 1st MBBS curriculum into 1 year came as a shock. The students were apprehensive and confused over this development. Even the faculty was sceptical and had reservations about the wisdom of this exercise. The conscientious faculty felt committed to the cause of the students that demanded intense and speedy action. Fortunately we had sufficient time to deliberate and devise methods for improvements.

Author's Affiliation: *Professor & Head, **Ex Professor & Head, Department of Anatomy, Armed Forces Medical College, Pune, 411040 ***Assist . Professor , Anatomy Dept. GMCH, Latur- 413512.

Corresponding Author: Col Sushil Kumar, Professor & Head, Department of Anatomy, Armed Forces Medical College, Pune, 411040.

E-mail: drsushilkumar@rediffmail.com

We started by holding a meeting with students' representatives from each dissection table once a fortnight. The outcome of the interactions motivated us to look into the following aspects of training:

- Prepare workbooks to facilitate taking down notes
- Organise revision bay
- Hold revisions to prevent backlog with students
- Counselling of slow learners
- Improving presentation in theory
- Evaluation of faculty by the students

Thereafter, we got the efforts put in by us evaluated by the students by way of a feedback. Accepting the premise that the major goal of an educational institution is to promote positive changes in students, we must look to students for feedback when we are evaluating our efforts to achieve that goal. Student

evaluation of teachers is probably the most common form of summative teacher evaluation. Students can provide valid evaluative information in four areas (1):

- Information about teaching methods - they know what works
- Fairness of the faculty member in the evaluation/ teaching process-students talk to each other and have a good sense of fairness
- Faculty interest in the student
- Faculty interest in the content of a course or subject-students like enthusiasm

Others have argued that students are not a good source of teacher evaluations, but many of the objections are not supported by published data (2-7).

Summative and perhaps formative evaluation of teachers, teaching methods, or courses should occur at the end of courses when there is little opportunity for students to see or reap benefits from their comments.

To make the evaluation purposeful we devised a questionnaire, which was given to the students after passing 1st MBBS examination. Data was compiled for three consecutive years. Students came up with suggestions and were forthright in pointing out the shortcomings of a particular teacher. Their views have been taken sportingly and efforts made to improve and comply with some of the worthy suggestions.

Aims and Objectives

- To get a feedback on the changes brought about in the teaching methodology so that it can be tailor-made to suit the requirement and expectations of the undergraduate medical students.
- To get the faculty evaluated by the students to iron out their shortcomings.

Material and Methods

A questionnaire was prepared comprising of three sections.

a) Views and feed-back on teaching and modifications practised throughout the year in:
   - Lectures
   - Tutorials
   - Histology
   - Dissection
   - Revision
   - Counselling

b) Evaluation of faculty and suggestions on who to teach what

c) Opinion and suggestions for improving overall standard of the department

This questionnaire was given to the entire batch after passing 1st MBBS. Thus the students could respond without any fear or prejudice of being victimised. The entire batch was made to sit in the lecture hall and respond to the questionnaire independently. Anonymity was maintained to ensure their frank opinions.

The procedure has been carried out for three consecutive years and data analysed.

Observations

The study subjects gave the feedback by answering the questionnaire. Not all students answered all the questions. In addition to just answering the questions, some students even gave their suggestions.

Table 1 : Feedback On Lectures

	1st Batch	2nd Batch	3rd Batch
Overall Lectures:(Good)	65/88 (73.86%)	67/102 (65.68%)	65/92 (70.65%)
Handouts to be given	12/88 (13.63%)	60/91 (65.93%)	49/98 (50.00%)
Seminars for some Lectures	59/88 (67.04%)	56/96 (58.33%)	66/96 (68.75%)

Majority of the students found that the overall lectures were good as shown in table-1. Some of the points highlighted for certain lectures were, being too elaborate, poor diagrams, improper use of audio-visual aids. The 2nd batch was not in favour of giving handouts prior to the lectures whereas half the students in 1st and 3rd batches wanted handouts.

Table 2 : Feedback On Tutorials

	1st Batch	2nd Batch	3rd Batch
Overall Tutorials:Satisfactory	64/92 (69.56%)	34/109 (31.19%)	58/87 (66.66%)
Question & Answersessions	60/92 (65.21%)	59/103 (57.28%)	69/83 (83.13%)
Osteology Workbooks: Helpful	-	81/94 (86.17%)	63/95 (66.31%)

The overall teaching during tutorials was found satisfactory except for the 2nd batch where 31% thought otherwise. Majority were of the opinion that it should be a question answer session. 86% of 2nd batchers and 66% of 3rd batchers found the workbook on osteology useful.

Table 3 : Feedback On Histology

	1st Batch	2nd Batch	3rd Batch
Overall Teaching:Good	80/86 (93.02%)	77/109 (70.64%)	79/96 (82.29%)
Journal: Useful	85/86 (98.83%)	80/102 (78.43%)	85/97 (87.62%)
Revisions: Useful	84/90 (93.33%)	98/109 (89.90%)	95/96 (98.95%)

Most of them considered the overall teaching of histology to be good. The students found the journal and revisions very handy.

Table 4 : Feedback On Dissection

	1st Batch	2nd Batch	3rd Batch
Current procedure:Satisfactory	80/85 (94.11%)	87/108 (80.55%)	82/96 (85.41%)
Followed byProsection	40/86 (46.51%)	46/86 (53.48%)	86/95 (90.52%)
Dissection Manual	-	43/72 (59.72%)	58/99 (58.68%)

The students were satisfied with the current dissection procedure being followed, however, half the '1st' and '2nd' batchers felt it would be better to have a prosection before hand. 90% of the '3rd' batch students wanted prosection first. Views over the dissection manual were equivocal.

Table 5 : Feedback On Revision

	1st Batch	2nd Batch	3rd Batch
Evening revision:Useful	57/105 (54.28%)	52/92 (56.52%)	85/102 (83.33%)
Small group teaching: Useful	62/102 (60.78%)	58/93 (62.36%)	68/102 (66.66%)
Affected othersubjects	10/106 (09.43%)	53/93 (56.98%)	28/105 (26.66%)

Half the students of the '1st' and '2nd' batches found the evening revisions useful whereas 83% of those of '3rd' batch found it worthwhile. A majority accepted that such classes should be conducted in small groups. 9% of students from '1st' batch and 27% of '3rd' batch did not find that revisions affected their study schedule whereas 57% of the '2nd' batch students felt that revisions did affect their study schedule.

Table 6 : Feedback On Counselling

	1st Batch	2nd Batch	3rd Batch
Counselling sessions:Useful	86/92 (93.47%)	72/83 (86.74%)	76/102 (74.50%)
Counselling beContinued	82/92 (89.13%)	68/80 (85.00%)	74/101 (73.26%)

Majority found the counselling sessions useful and opined that it should be continued.

The feedback on the evaluation of the faculty was very illuminating. Besides the senior teachers, some junior teachers were also ranked high.

Some of the impressions and/or feelings about participating in the process were as follows:

- Very helpful as it creates a better learning environment.
- Requires that the class perceive the facilitator to be fair.
- Nice that a professor cares enough about our education to put his head on the block.
- Specific problems in the course can be addressed.
- Very helpful, providing the instructor keeps an open mind about the criticisms.
- Excellent opportunity for changing course when changes can make a difference.
- A lot easier to remember likes and dislikes when other people bring them up.
- Good method of providing suggestions for improvements but also giving positive reinforcement.
- Very impressed that instructor cares enough about our opinion to take a class session to ask.
- Hope that since the teacher initiated the process, suggestions will be followed or considered.
- Will greatly help the teacher to efficiently teach the class.
- Thank you for caring what we think, we usually get ignored.

Discussion

Feedback from students is generally regarded as an effective way to improve teaching; there are studies that support this notion (8-19). In some medical centres student evaluations are used to help determine promotion. It is the general consensus that students are, in fact, capable of providing fair teacher evaluations (20-23). Some of the junior faculty were rated higher than their senior colleague's highlighting the fact that the opinions of the students were unbiased based solely on their ability to teach a given topic.

Although apparently fair and capable of leading to improvement in a lecturer's performance, another important issue is whether student ratings of lecturers are reliable (i.e., consistent and reproducible). Again the general consensus in the medical literature is that good reliability has been demonstrated over a variety of courses, instructors, and students within the medical setting (9, 11–19, 20, 22-24).

The opinion of our students did have some very astounding responses. The views expressed by the students highlighted the grey areas for some lectures and tutorials. This helped us to change and improve the teaching methodology for subsequent classes. Since only fifty percent wanted handouts, we did not find it to be a priority job. Some seminars are being planned in place of certain lectures. This should benefit the students because it will involve their active participation.

The junior faculty is conducting tutorials, which include trainees and ad-hoc demonstrators. The low satisfactory score by 2nd batch students forced us to do some serious thinking. Efforts are on to convert the tutorials into an interactive session. Since ostelogy workbooks have been found useful the department has prepared the same.

The paucity of cadavers and compression of 1st MBBS duration has forced us to have prosection in place of some dissections. Students have found them very useful and have demanded that each dissection be followed by a prosection. This no doubt will increase the understanding and reduce the time taken to complete the particular dissection.

The equivocal response to revision by the earlier batches made us alter the revision schedule to meet the demands of the students. Senior teachers conducting revisions for the weaker lot has made the difference.

The effort put in counselling was essentially to find out the malady and look for the remedy. By and large, all those who were identified as slow learners had a multifactorial genesis. Sincere effort was put in to recoup these students. It was heartening that once the rapport was established, most of the students opened up and one could see their pride getting restored. It indeed made our day to find that the slow learners gradually climbed the rungs of performance in their scholastic pursuits.

The ranking of the teachers has infused a sense of competition amongst them to strive for the better, at the same time it has shaken a few from their slumber of complacency. All of us have taken these in the right spirit. Going by the preferences of topics to be taken by a teacher, the subsequent teaching schedule has been modified.

Summary and Conclusion

Student feedback is a technique for improving the teaching/learning relationship and assumes the following principles:

- Learning is an active process and student involvement is essential;
- Student perception of and interaction with the teacher is integral to the process of learning;
- It is important for the teacher to see him/herself through the eyes of the student in order to build on the strengths of the relationship and correct the deficiencies;
- Students can make important contributions to the teaching/learning relationship and the teacher must be receptive to these ideas;
- Teaching and learning involve a dynamic relationship that can and should change with time and experience. There is no one "correct" way for teaching and learning. One should strive to find new and better methods.

Having said so, we would however like to add that such feedback from students should be viewed very judiciously. Poor judgmental power, feeling of fun while giving feedback and obnoxious comments reflects loss of interest in feedback (25). Many time students fail to give specific response due to ambiguous question. However providing structured pre-tested proformas with specific questions can enhance the reliability of a feedback. Incorporation of suggestions in subsequent sessions is necessary not only to bring some positive changes but also to encourage students to maintain their interest in feedback

References

1. Dennis LI: Student evaluations: are they an appropriate criterion for promotion? *Nursing Health Care* 11:79-82, 1990.
2. Bell DF, Miller RI, Bell DL: Faculty evaluation: teaching, scholarship, and services. *Nurse Educator* 9:18-27, 1984.
3. Turnwald GH, Bull, KS, Young KM, Seeler DC: Student evaluation of instruction: implications for veterinary medical education. *Jour Vet Med Educ* 19:37-44, 1992.
4. Morton PG: Student evaluation of teaching: potential and limitations. *Nursing Outlook* 35:86-88, 1987.
5. Ward-Griffin C, Brown B: Evaluation of teaching: a review of the literature. *J Adv Nursing* 17:1408-1414, 1992.
6. Boice R: Countering common misbeliefs about student evaluations of teaching. *Teaching Excellence* 2(2): 1990-1991.
7. Lancaster CJ, Mendelson MA, Ross GR: The utilization of student instructional ratings in medical colleges. *J Med Educ* 1979;54:657–9.
8. Stern DT, Williams BC, Gill A, et al: Is there a relationship between attending physicians' and residents' teaching examination scores? *Acad Med* 2000;75: 1144–6.
9. Stillman PL, Gillers MA, Heins M, et al: Effect of immediate student evaluations on a multi-instructor course. *J Med Educ* 1983;58:172–8.
10. Rippey R: *The Evaluation of Teaching in Medical Schools*. New York, Springer Publishing, 1981, pp 14–31.
11. Albanese MA, Schroeder J, Barnes V: Student perceptions of instruction: Assessment in a multiple instructor course which maximizes student response. *Eval Health Prof* 1979;2:231–239.
12. Irby DM, Shannon NF, Scher M, et al: The use of student ratings in multiinstructor courses. *J Med Educ* 1977;52: 668–73.
13. Gromisch DS, Bamford JC Jr, Rous SN, et al: A comparison of student and departmental chairman evaluations of teaching performance. *J Med Educ* 1972; 47:281–4.
14. Bandaranayake RC: Utilization of feedback from student evaluation of teachers. *Med Educ* 1978;12:314–20.
15. Rous SN, Bamford JC Jr, Gromisch D, et al: The improvement of faculty teaching through evaluation: A followup report. *J Surg Res* 1972;13:262–6.
16. Feinstein E, Levine HG: Impact of student ratings on basic science portion of the medical school curriculum. *J Med Educ* 1980;55:502–12.
17. Litzelman DK, Stratos GA, Marriott DJ, et al: Beneficial and harmful effects of augmented feedback on physicians' clinical teaching performances. *Acad Med* 1998;73:324–32
18. Schum TR, Yindra KJ: Relationship between systematic feedback to faculty and ratings of clinical teaching. *Acad Med* 1996;71:1100–2.
19. Nevalainen DE: Student evaluation of instruction: a challenge to medical technology educators. *Am J Med Technol* 1977;43:782–4.
20. Burton CE: *College Teaching*. New York, Harcourt, Bruce, and Javanovich, 1956.
21. Bejar II: A Survey of selected administrative practices supporting student evaluations of instruction programs. *Res Higher Educ* 1975;3:77–86.

22. Costin F, Greenough WT, Menges RJ: Student ratings of college teaching: Reliability, validity, and usefulness. *Rev Educ* 1971;41:511–535.

23. Miller RI: *Evaluating Faculty Performance*. San Francisco, Jossey-Bass, 1972.

24. Baggott J: Reaction of lecturers to analysis results of student ratings of their lecture skills. *J Med Educ* 1987;62:491–6.

25. Panna Lal, Srinivas G, Gautam Roy, Mishra A. Feed-back given by undergraduate medical students after a teaching session: Does it carry any meaning? Bulletin of NTTC, JIPMER 2001: 8; 5-6.

Original Article

Indian Journal of Anatomy
Volume 3 Number 4, October - December 2014

A Study of Morphology and Relations of Iliocava Junction to Aortic Bifurcation and Lumbosacral Vertebrae

Kulkarni Saurabh P*, M. Natarajan**

Abstract

Growing interest of surgeons in anterior approach to lumbar spine has demonstrated its vascular complications. A clear delineation of vascular working window for operating lumbar spine, formed by inferior vena cava formation and Aortic bifurcation is important to avoid dangerous complication. This study determines common level of Aortic bifurcation at the body of L4, with average distance of 34mm from lower border of L5-S1 disc. Variable level of iliocava junction (formation of inferior vena cava) was noted from body of L4 to L5-S1 disc, with average distance of 17mm from lower border of L5-S1 disc. Average width of inferior vena cava measured maximum at its formation i.e. 28mm. Width of right and left common iliac vein found almost equal. Angle made by left common iliac vein with inferior vena cava found most variable whereas that with right common iliac vein was constant. Average interiliac angle was 72.5 degrees. Left common iliac vein showed average 3 tributaries while right showed none or 1.

Key words: Iliocava junction; Aortic bifurcation; Lumbosacral spine.

Introduction

Venous anatomy is known for variations. Lots of variations of inferior Vena cava are encountered during cadaveric dissection and while operating on lumbosacral spine. Variations of its formation (Iliocava Junction) are the most common amongst them.

Prolapsed intervertebral disc or malignant vertebral tumors and even vertebral body fusion procedures are common indications for surgeries for low back pain. Posterior approach to this region has been recorded less satisfactorily, which led to a growing interest in anterior approaches to the lumbar spine. Anterior approach lumbar surgery and reported results from laparoscopic surgery have demonstrated that such approach can be associated with dangerous vascular complications.This makes detail study of vasculature at lumbosacral spine specially iliocava junction vital.(1)

The CT study by Svin Anda ,Svend Aakhus, Karl Ove Skaanes reported that inferior vena cava and left common iliac vein which forms vascular working window of operating field have a larger transverse diameter and lie closer to the disc than do the arteries. Because veins have considerably thinner wall than arteries, veins can be inadvertently hit and punctured resulting into formation of hematoma with false aneurysm or arteriovenous fistulas.(2)

A clear delineation of vascular anatomy and its relationship to the disc space would provide useful information to the surgeon for the approach to the field, especially during laparoscopic procedures . Study may be useful for radiologist to determine types of variations. This study is done for assessment of morphology of iliocava junction and defines its relationship with lumbosacral spine and aortic bifurcation.

Author's Affiliation: *Assistant Professor, Department of Anatomy, Government Medical College, Aurangabad. ** Professor, Department of Anatomy, Seth G S Medical College and K E M Hospital, Parel, Mumbai.

Corresponding Author: Dr. Kulkarni Saurabh P, Assistant Professor, Department of Anatomy, Government Medical College, Aurangabad.

Aim and Objectives

To study Aortic Bifurcation with respect to:

- Vertebral level
- Distance from lower border of L5 vertebra
- Width

To study Iliocava junction with respect to:

- Vertebral level ,
- Variations of formation, Iliocava junction position (above or below aortic bifurcation) .
- Width of iliocava junction.
- Width of inferior vena cava 2 , 3 and 4 centimetres above iliocava junction .
- Distance between aortic bifurcation and iliocava junction.
- To measure angle between two common iliac veins,
- Angle between inferior vena cava and right common iliac vein,
- Angle between inferior vena cava and left common iliac vein.
- To measure width of right and left common iliac vein.
- To measure distance between two common iliac veins at lower border of L5 vertebra.
- To determine number of tributaries opening into iliocava junction and both the common iliac veins.

Material and Methods

This study was done on inferior vena cava of 60 cadavers. Cadavers were embalmed with 10% formalin. The cadavers used were first dissected by First MBBS students. Students dissected anterior abdominal wall, studied abdominal viscera. They were asked to preserve inferior vena cava for measurements of study according to proforma.

Area of study included aortic bifurcation, iliocava junction with proximal 4 cm segment of inferior vena cava and first sacral & lower lumbar vertebrae. Area dissected meticulously and all soft tissue made free from surrounding fat. Clotted blood in inferior vena cava removed.

Position of aortic bifurcation noted. Its distance from lower border of L5 vertebra measured (Height of aortic bifurcation) with measuring tape. (Illustration 1) Width of aortic bifurcation measured.

Position of inferior vena cava noted with respect to its vertebral level, either right or left to aortic bifurcation and either above or below aortic bifurcation. Distance of formation of inferior vena cava (Iliocava junction) from lower border of L5 vertebra measured (Height of Iliocava junction). Width of Iliocava junction measured. Width of Inferior vena cava 2 centimetres, 3 centimetres and 4 centimetres above Iliocava junction measured.Width of right and left common iliac veins measured. (Illustration 2)

With the help of goniometer angle between two common iliac veins (Interiliac angle), angle between inferior vena cava and right common iliac vein(Right Iliocaval Angle), angle between inferior vena cava and left common iliac vein (left Iliocaval angle) measured(Illustration 3).

Distance between two common iliac veins at lower border of L5 vertebra was measured. Number of tributaries opening at iliocava junction and both common iliac veins noted.

Results

- The aortic bifurcation was situated between L3-L4 disc to L4 - L5 disc more frequently at the level of body of L4 i.e. 44.99%.
- The average height of the aortic bifurcation was 34 mm (± 8.87).
- The mean width of aortic bifurcation was 20.5 mm (± 2.16).
- Iliocava junction was on the right side and superior to the level of aortic bifurcation in all cadavers.
- The iliocava junction was situated between middle 1/3 of body of L4 to disc space between L5 and S1, and more frequently at disc space between L4 and L5 i.e. 41.66%.
- The average height of iliocava junction was 17 mm (± 6.49).
- The iliocava junction was always to the right side of sagital axis passing through the aortic bifurcation.
- The average distance between aortic bifurcation and iliocava junction was 26 mm (±4.96).

- The average width of inferior vena cava was maximum at the level of junction i.e. 28mm (±2.96). Width was found decreasing on measuring 2 centimeters to 4 centimeters successively.
- The average width of right common iliac vein was 20 mm (± 2.54)
- The average width of left common iliac vein was 19.7 mm (± 3.01). Thus no significant difference was found in width of right and left common iliac veins.
- The average interiliac angle was 72.5 degrees (± 9.07). 13. The average right iliocava angle was 162.5 degrees (± 7.18)
- The average left iliocava angle was 125 degrees (±11.81) .
- The average distance between two iliac veins measured at lower border of L5 was 43mm (±6.57).
- Average number of tributaries opening in left common iliac vein was 3 (± 0.41). Tributaries opening in IVC and right common iliac vein were 0-3.

Discussion

Area of formation of IVC by joining of two common iliac veins and bifurcation of abdominal aorta is of interest for radiologists and surgeons. Literature records many CT and MRI based studies of vascular anatomy inrelation to lumbar vertebrae.(3)

A study by Norio Kawahara , Katsuro Tomita and others in Kanazawa university Japan(38) concludes that vertebral tumors involving L3 and L4 can be approached by posterior *en bloc* spondylectomy but , for L4 , it is recommended to be done anteroposteriorly, mainly because of direct contact of IVC with vertebral column. Authors also recommend combined anterior and posterior approach for L5 tumor for anatomic complexity of major vessels at this level in addition to structural difficulty presented by iliac crest. Svein Anda and Svend Aakhus, neurosurgeons from Norway reports importance of detail knowledge of prevertebral lumbar vascular anatomy in a CT study done for evaluating vascular complications of anterior perforation discectomies. This study shows that IVC and common iliac veins have larger diameter and lie closer to the disc. They form broad vascular band especially at L4-L5 disc level. Therefore veins hit and punctured in anterior perforations.(4)

A cavographic study on infra renal segment of IVC by Bonnichon and Gaudard from Paris , France depicts diameter of IVC helps in caval filter placement. Thus it is clear that the trans peritoneal laparoscopic approach to the lumbosacral spine has become an increasingly common procedure both in spine surgery and in surgery of pelvic floor diseases. The iliocava junction and aortic bifurcation present the major limit to extensive exposure at this level.(5)

Radiological and cadaveric studies have related an important variability in the vascular structures adjacent to the lumbosacral spine. Site of aortic bifurcation is classically described at the level of L4 vertebral bodies. The aortic bifurcation occurs anywhere from body of L3 to L5. Present study has AB at L4 level in 44.99%. Similar study in cadavers by S. Pirro and D. Ciampi shows AB in 50% cases. By understanding limitations of study in cadavers, arteriographic, CT and MRI have recently been utilized for studying vascular anatomy AB. MRI study on 441 patients of lumbar vertebral disease at Michigen USA by M Chithriki and M Jaibaji(6)

reports 67% AB at L4 vertebra.

Table 1 : Comparison with Level of Aortic Bifurcation in Between M R I Study of M. Chithriki and M. Jaibaji and Present Study (6)

Vertebral Level	% of Patients in MRI Study	% of Cadavers in Present Study
Upper L3	0.9	-
Middle L3	1.4	-
Lower L3	7.0	-
L3-L4 disc space	13.4	28.33
Upper L4	19.1	20.00
Middle L4	24.0	1.66
Lower L4	23.8	23.33
L4-L5 disc space	7.7	26.66
Upper L5	1.6	-
Middle L5	0.9	-
Lower L5	0	-

This study also correlated incidence of vertebral anomalies like sacralisation and lumbarisation of vertebrae with level of AB. Study reports 8.4% cases with lumbosacral anomalies and states that location of the AB to be more cephlad in those with sacralisation and at a more caudal level in those with lumbarisation . In the present study there were no anomalies at the Lumbosacral junction. Lerona and Tewfik studied similar parameters in 100 pelvic arteriogram, but study was limited to females with pelvic malignancies. In same studies iliocava junction is more consistent in its location than aortic bifurcation.

The iliocava junction is related to L4-L5 disc level or to the L5 body level. Present study shows it at L4-L5 disc level in 41.33 % and at L5 body level in 48%, out of which 25% was found in lower third of the L5 body. Study by S. Pirro and D. Ciampishows 64% ICJ at L5 body. MR angiographic study by Jaume Capellaudes and Farran Pellisefocuses on vascular working window dependant on position of ICJ and Left Common Iliac Vein(CIV). This is important for anterior lumbar inter body fusion procedure. Study reports ICJ at L5 body level in 59.4 % cases. ICJ is reported at L5-S1 disc in 10% in MR angiographic study, 12% in study by S. Pirro and D. Ciampi and inonly one case in present study.

Only one radiological study, with 134 patients undergoing MRI for low lumbar pain by Jaume Capellaudes and Farran Pellise , has evaluated the position of the iliocava junction in relation to age and sex. Moreover this study included patients with spondylosis. Spondylosis and loss of disc height may contribute to the variability in vascular anatomy and modify relations between vessels and lumbosacral spine. The possibility of ethnic variations was mentioned.

The iliocava junction and the angle between two Common Iliac Veins (CIV) -interiliac angle determine the accessibility to the L5-S1 disc. The interiliac angle is as variable in anatomical studies as in radiological studies. The interiliac angle was found to depend on the height of iliocava junction in study of Jaume Capellaudes and Farran Pellise , which considered the iliac veins as having a constant endopelvic route between iliocava junction and other vascular structures. The vascular window located under iliocava junction between the two common iliac veins is main access to the L5-S1 disc. The height of iliocava junction and the position of left common iliac vein are the main predictive factors for anterior approach to L5-S1 disc. Same radiological study observed that the left common iliac vein was more medial in men than in women at L5-S1 disc. Two radiological studies show that vascular window is narrow in one third of the cases. However, the main criteria used in these studies for accessibility can not help in avoiding surgical complications. Only one retrospective study of KleemanTj and MicheilAhn U has compared iliocava convergence and the aortic bifurcation, evaluated by computed tomography with preoperative anatomy.(7)

With the development of cross-sectional imaging, anomalies of inferior vena cava have frequently been revealed on CT. These anomalies may be associated with widespread thrombosis of the iliac and femoral veins, particularly in young patients.

Gayer et al reports nine patients with an inferior vena cava anomaly who presented with widespread deep vein thrombosis of the pelvic and femoral veins. They studied first time this series of patients whose CT findings showed the uncommon association of congenital anomalies of the inferior vena cava with deep vein thrombosis.(3)

Anomalies of the inferior vena cava have been recognized as a possible risk factor for deep vein thrombosis, particularly in young adults, with only anecdotal CT descriptions. Ruggeri et al.found an anomalous inferior vena cava in four of 75 young patients with a first episode of deep vein thrombosis. Those authors estimated the prevalence of an anomalous inferior vena cava in that group of patients to be around 5.3%, but they assumed that their figures were necessarily conservative because some cases might have been missed by an incomplete radiology study or inadequate awareness of the possible causative relationship of an inferior vena cava anomaly with deep vein thrombosis. Obemosterer et al prospectively evaluated 31 patients with ileofemoral deep vein thrombosis on venography and MR angiography and found five with anomalies of the inferior vena cava. Authors also found a high prevalence (9.5%) of an anomalous inferior vena cava in young patients with deep vein thrombosis, instead of an expected rate of about 0.3% . The ideal imaging modality to help diagnose an IVC anomaly must have high diagnostic accuracy and also be safe and reproducible. It is difficult to establish a diagnosis of any IVC anomaly by ultrasound. Various clues are recognized on radiologic imaging that could help diagnose an absent IVC or anomaly. One of the more common and helpful clues is well developed and possibly dilated intrathoracic hemiazygous and/or azygous continuations. These collateral circulations as well as other retroperitoneal venous pathways are usually well developed before symptoms present.(8)

The most reliable, non-invasive methods to establish a diagnosis of IVC anomalies are CT with

intravenous contrast or magnetic resonance scan. CT scan, unlike ultrasound, is a good imaging modality of the retroperitoneal space. Another accurate, but more invasive, imaging modality is venography, which is particularly useful if any surgery is planned.

Illustration 1

Illustration showing measurement of height of aortic bifurcation

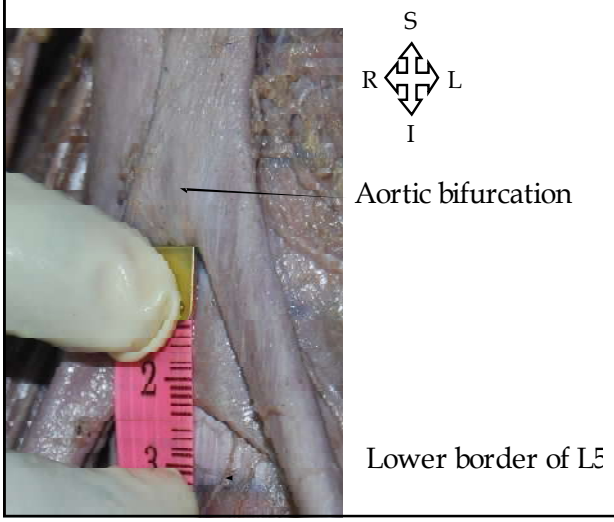
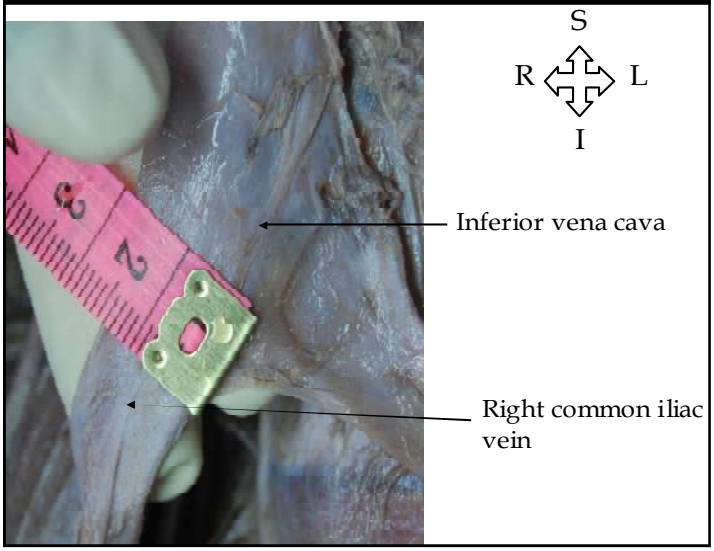


Illustration 2

Illustration showing measurement of width of right common iliacvein



It is hypothesized that blood return with an absent IVC is inadequate, despite adequate collaterals, resulting in chronic venous hypertension in the lower extremities and causing venous stasis that precipitates thrombosis.

Gayer et al recommended that all patients with an IVC anomaly be screened for a thrombophilic disorder. In their series, 7 of 9 patients with an IVC anomaly and DVT had a positive thrombophilic screen. There have been 3 case reports in the medical literature of thromboembolism due to an IVC anomaly (absence of the infrarenal portion of the IVC, infrarenal IVC hypoplasia). In all of these cases, the thrombophilic screen was negative. It was hypothesized that multiple emboli from DVT in the common and superficial femoral veins migrate through the well-developed hemiazygous and/or azygous system to the pulmonary circulation.

There is very little evidence available on the surgical correction or the treatment of this uncommon anomaly. A case report of a complete absence of the IVC but patent iliac veins and nonhealing pretibial ulceration described successful treatment with a prosthetic graft from the iliac vein to the intrathoracic azygous vein. Success was defined as complete healing of the ulcer up to 30 months after surgery.

Knowledge of the association of other anomalies in patients with an absent IVC, such as renal atrophy or agenesis, can highlight underlying vascular anomalies, which are in themselves of significant clinical importance. Clinician must have a profound awareness of the associated elements that make up the clinical complex of congenital vena caval abnormalities in order to avoid diagnostic and treatment pitfalls.

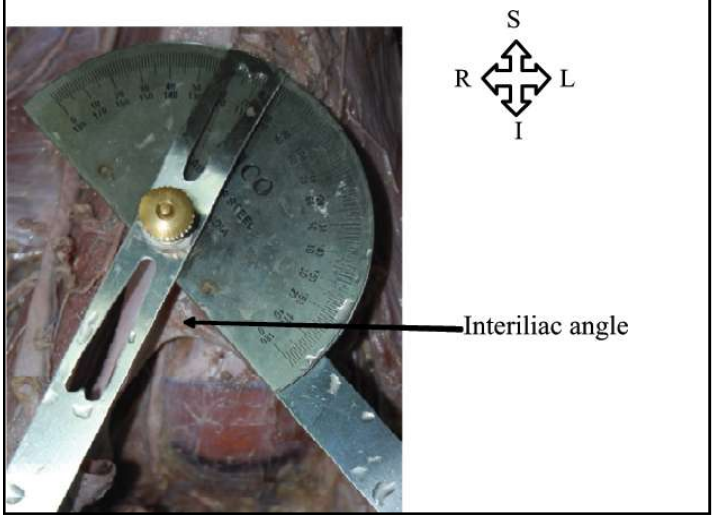
Conclusion

This study focuses on the anatomical relation of lower lumber spine with great vessels in abdomen. Anatomically they are placed in such a way that approach to lumber spine involves risk of vascular damage. So , as proven by various referred studies congenital anomalies specifically of formation of Inferior vena cava , and their respective relation with Aortic bifurcations plays crucial role in defining working window for surgery.

With the increased incidences of patients requiring surgeries for malignancies of vertebrae, spondylolisthesis, tuberculosis, vertebral body fusion, prior CT evaluation of vascular anatomy is advocated specifically when laparoscopic mode is planned.

Illustration 3

Illustration showing measurement of interiliac angle



This will also help in anticipating different medical conditions associated with various anomalies. It has importance in irradiation procedures too , which may be indicated for common gynaecological malignancies having high risk of vascular complication.

References

1. Pirro S, Ciampi D .The anatomical relationship of the iliocava junction to the lumbosacral spine and aortic bifurcation. SurgRadiol Anatomy (2005) 27; 137-141.
2. Anda S, Aakhus S, Skaanes KO, Sande E, Anterior perforations in lumbar discsctomies. A report of four cases of vascular complications and a CT study of the prevertebral lumbar anatomy. Spine (1991) 16:54-60.
3. Gayer G, J. Luboshitz M. Hertz R. Zissin M. Thaler A. Lubetsky, A. Bass, A. Korat and S. Apter Congenital Anomalies of the Inferior Vena Cava Revealed on CT in Patients with Deep Vein Thrombosis http://www.ajroline.org.
4. Kawahara N , Tomita K, Baba H , Toribatake Y, Fujita T, Mizuno K , Tanaka S; Cadaveric vascular anatomy for total en bloc spondylectomy in malignant vertebral tumors . Spine (1996) 21:1401-1407.
5. Bonnichon , Gaudard F Biometry of infrarenal inferior vena cava measured by cavagraphy, surg and radiolAnat; (1989) 11 : 149-154.
6. Chitriki M, JaibajiM , Steele RD The anatomical relationship of the aortic bifurcation to lumbar vertebrae : a MRI study . SurgRadiolAnat; (2002); 24:308-312.
7. Capellades J , Pallise F , Rovira A, Grive E, Pedraza S, Villanueva C Magnetic resonance anatomic study of iliocava junction and left iliac vein positions related to L5-S1 disc. Spine (2000) ; 25:1695-1700.
8. Lerona PT, Tewfik HH Bifurcation level of aorta : landmark for pelvic irradiation. Radiology (1975) 115:735.

Original Article

Indian Journal of Anatomy
Volume 3 Number 4, October - December 2014

Anthropometric Data of Hand and Middle Finger Length in Both Sexes of College Students and its Correlations with Stature

G.A. Shroff [*], Mandhana V.S.[**], Mois Khawja[***]

Abstract

Background: Estimation of an individual's stature is an important parameter in forensic examinations and anthropological studies. Morphometry of the hand provides important evidence in a crime scene investigation which helps in the estimation of stature of a criminal.Moreover, there can be anthropometric variations in different geographical areas. Aim: Determination of standard data of stature, hand length and middle finger length. To obtain correlation between these parameters. **Material and method:** 260 students were measured with 130 male and 130 Female candidates. Descriptive statistical analysis with distribution of population by skewness and Kurtosis are analyzed. Correlation between parameters were calculated with SPSS. **Result:** Middle finger length with hand length is highly correlated with pearson Correlation 0.896 for left side and 0.892 for right side. Both parameters are Correlated with Height of person by linear correlation. Multivariaent regression equations are calculated. **Conclusioin:** Both hand length and Middle finger length are linearly correlated with height of person. Multiveriate regression formulas are useful to calculate structure of person. These parameter are useful in ergonomics.

Keywords: Stature; Hand length; Middle finger length; Correlation coefficient.

Introduction

Adaptation of the upper extremity due to bipedal locomotion in human make the upper limb free from the burden of weight bearing. Hand become organ of prehension to manipulate the environment by a grasping mechanism.[1]

The study attempts to provide the anthropometric dimensions of the hand, foot and ear for the students in tertiary institutions in Nigeria. The study is necessary because differences in these dimensions as a result of gender and nationalities may consequences on the design and construction of handles, gloves, foot wears, brake pedals, ear-phones and so on. [2].

JasujaO. P. estimating stature from various parameters based on the above mentioned evidences becomes one of the most important and essential exercise for personal identification .In present paper, study on stature estimation from hand and phalanges length has been reported in 60 people. [3]

Ilayperumastudied was carried out to investigate the relationship between personal stature and hand length among a group of male and female Sri Lankan adults and to derive a linear regression formula between the handlength and height of an individual. total of 258 individuals with an age range of 20-23 years. [4].

From the present study we found somemultiplication factors which were helpful for Bengaliadult Muslim females for estimation of stature fromrespective hand length. That may be helpful forthose who work in this area especially in the

Author's Affiliation: *MS Anatomy; Professor and HOD Anatomy, Department of Anatomy, MGM Medical College, Aurangabad., ** MD Anatomy; Assit. Professor, Department of Anatomy, MGM Medical College, Aurangabad.,***Tutor, Department of Anatomy, MGM Medical College, Aurangabad.

Corresponding Author: Dr. Gautam Ajit Shroff, Magan Clinic, MachaliKhadak, Aurangabad 431001 Work Place: MGM Medical College, CIDCO N-6, Aurangabad.

E-mail: gashroff2006@gmail.com

variousmedical disciplines, anthropologists, and securityexperts of Bangladesh. [5]

Human beings are considered to be bilaterally symmetrical. However, there is an asymmetry in the length of the feet irrespective of sex or handedness. One hundred normal subjects (50 males and 50 females) between the ages of 19 and 25 years with no obvious deformities or previous history of trauma to the hands or feet were selected for the study. [6]

Rahulkestudy was planned to evaluate the correlation between middle finger length and stature of a tribal district population of India so that a formula can be derived for estimation of height for this tribal district population. A total of 100 subjects, 23 male and 77 female were included in the study. In the studiedpopulation middle finger length and stature among males and females have good correlation.[7]

In our study we found that there is strong correlation between stature and hand length and the linear regression analysis of the obtained data has provided the regression equations for nearly accurate estimation of stature in Gujarati population. Estimation of stature from hand length in Gujarat region [8]

Sample of 273 living cases (138 male and 135 female students) between the ages of 17 and 23 years with no obvious deformities or previous history of trauma to hands, feet, spine and limbs, were studied. This study shows significant correlation between stature and all five parameters at different degrees. Mathematical formulas were used for estimation of stature from Arm span, Hand length, Hand breadth, Foot length, and Foot breadth. Arm span showed the highest correlation with stature (r=0.908) followed by Hand length, followed by foot length. Hand Breadth showed the lowest degree of correlation (0.467). [9].

100 males and 100 females each containing 50 North Indian and 50 South Indian males and females, aged between 18-21 years. Present study shows higher mean values in each anthropometric dimension were obtained in males than in females. As far as the bilateral asymmetry is concerned, both hand length and width in North and South Indian males and females were statistically significant. In males the highest correlation co-efficient is exhibited by right hand length. Thus, hand length is the best parameter for estimating stature for males. [10]

Material and Method

Ethical committee permission was taken prior to study. Information sheet was given to allsubjects and written informed consent was obtained.

In this study total of 260 students of age group of 18 to 21 years taken with 130 male and 130 female. Care is taken that no one is has history of accident with fracture of extremity and not suffering from diabetic.

For measurement of hand length, both

hands was measured with VernierCalliper length was measured from tip ofmiddle finger or the longest finger to thecentre point of inter styloid line.

Middle finger is measured from tip of finger till proximal crease of phalange in cm.

Standing height was measured with the

individual standing barefoot on theplatform of the stadiometer with the upperback buttock and heels pressed against theupright position of the instrument. Headwas positioned in the Frankfort horizontalplane, and the head plate was brought intofirm contact with the vertex.

Data was tabulated. Discreptive statistical and ratio between hand length and middle finger length was calculated. Test of significance applied. And Correlation

coefficient was calculated with regression equation by SPSS 19.

Results

Height is one of the indicator of identity of individual. Descriptive analysis of data indicates significant difference in male and female parameters. Both one way ANOVA and t-test signifies values 0.000.

Range of male height in male population is 147 to 193 cm and female population is 124 to 180.34 cm. Normal distribution shows mesocertic distribution of population. F value is 206.528 and highly significant 0.000.

Hand length and middle finger length shows difference in length in both right and left hands with significant difference in both sexes.

Table 1: Height in (cm)

	Male	Female
Mean	171.49	157.98
Std. Dev.	7.56	7.59
Std. Er. Mean	0.66	0.67
Min	147	124.46
Max	193.04	180.34
Skewness	-0.158	-0.905
Kurtosis	0.576	0.212

Fig. 1: Graph of mean Height in cm

Table 2 : Hand Length in cm

	Male		Female	
	Right	Left	Right	Left
Mean	18.67	18.72	17.34	17.27
Std. Dev.	0.94	0.95	1.23	1.15
Std. Er. Mean	0.08	0.08	0.1	0.04
Min	16	16.3	15.3	15.2
Max	21.7	21.8	24	21.6
Skewness	0.24	.25	1.66	1
Kurtosis	0.94	0.58	6.01	1.63

Table 3 : Middle Finger Length (cm)

	Male		Female	
	Right	Left	Right	Left
Mean	8.16	8.18	7.45	7.43
Std. Dev.	0.46	0.46	0.55	0.54
Std. Er. Mean	0.04	0.04	0.04	0.04
Min	7	7	6.2	6.2
Max	9.8	9.8	9.3	9.2
Skewness	0.19	0.28	0.74	0.62
Kurtosis	0.63	0.72	0.79	0.61

Fig. 2 : Hand Length Mean Values

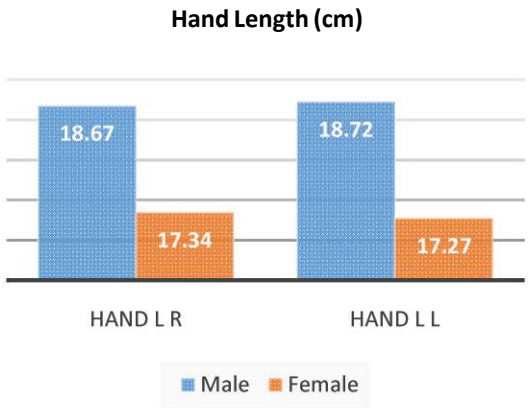
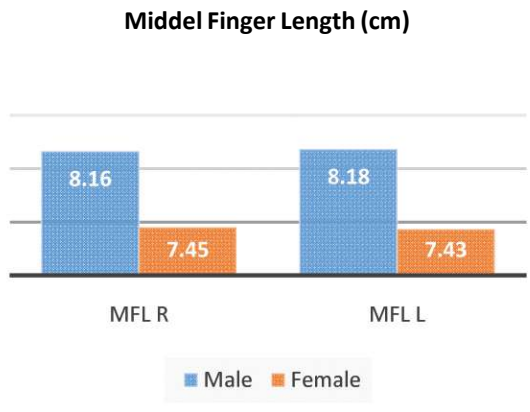


Fig. 3 : Middle Finger Length (cm)



Eq3: Height = 85.945 – 2.947 * Right hand length + 4.991 * Left hand length + 5.302 * Right middle finger length + 0.080 * Left middle finger length (R= 0.59).

Discussion

Estimation of an individual's stature is an important parameter in forensic examinations and anthropological studies. Morphometry of the hand provides important evidence in a crime scene investigation which helps in the estimation of stature of a criminal. The available data usually apply to Caucasians in Europe or North America.Only few studies of other racial groups exist which emphasize the need to establish standards in different ethnic populations[4].

In this study students from central India has been calculated. Mean value for height is higher in male than in female population.

Table 4 : Comparison of Hand Length (cm)

Sr.No	Authors	Measurements	Sex	Side	Min	. Max	Mean	± SD	± SE
1	Prasana L C	Hand length	Male North	Right			18.78		
				Left			18.8		
			Female North	Right			17.58		
				Left			17.52		
			Male South	Right			18.42		
				Left			18.44		
			Female South	Right			17.67		
				Left			17.59		
2	SZ Laila	Hand length	-	Right	-	-	16.39	0.79	-
				Left			16.34	0.8	
3	Jasuja[34] (2003)	Hand length	Male	Right	18.4	21.3	19.06	0.73	0.13
				Left	18.2	21.2	19.06	0.76	0.13
			Female	Right	19.1	19.7	17.32	0.81	0.14
				Left	19.1	19.9	17.24	0.8	0.14
4	Ommen	Hand length	Male	Right	-	-	19.85	0.86	
				Left			19.93	0.93	
			Female	Right	-	-	18.51	0.66	
				Left			18.52	0.77	
5	Ilayperuma[55] (2009)	Hand length	Male	-	-	-	19.01	5.22	-
			Female	-	-	-	17.62	0.93	-
6	Patel P N	Hand length		-	-	-	17.75	1.09	-
7	Patel J	Hand length	Male	Right			18.89		
				Left	-	-	18.86	-	0.08
			Female	Right			17.11		
				Left	-	-	17.08	-	0.11
8	Present Study (2014)	Hand Length	Male	Right	16	21.7	18.67	0.93	0.081
				Left	16.3	21.8	18.72	0.95	0.084
			Female	Right	15.3	24	17.34	1.23	0.1
				Left	15.2	21.6	17.27	1.14	0.1

With statistically significant. As also observed by Jasuja O.P., Patel J, but comparative values are higher than present study [3,8].

Hand length shows higher values in male than in female as in other studies. Correlation coefficient are on higher side in present study than in Jasuja O.P.; IlayerumaIsurani; Laila SZ; Patel J.Oommen A.; Prasana L. L. [3-8].

Very few studies had been carried out on middle finger length as in Rahule [7]. It shows good correlation with both height and Middle finger length. Middle finger length on right side is more in male than female. Regression equations had been calculated with multiple regression. With improved correlation coefficient. Rest other studies shows univariate analysis.

Fig. 4 : Comparision of Height

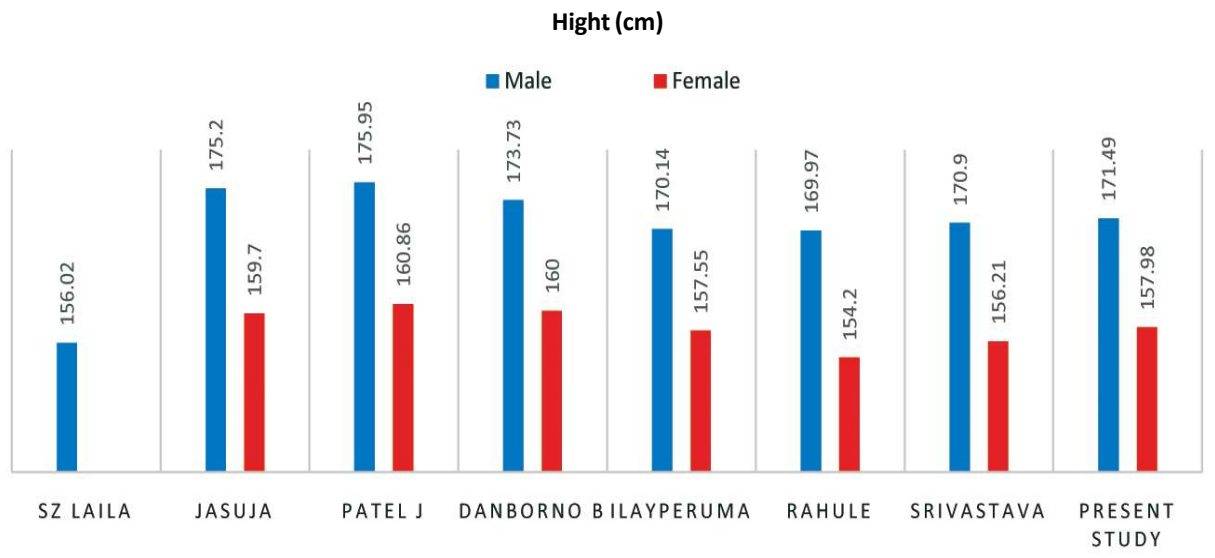
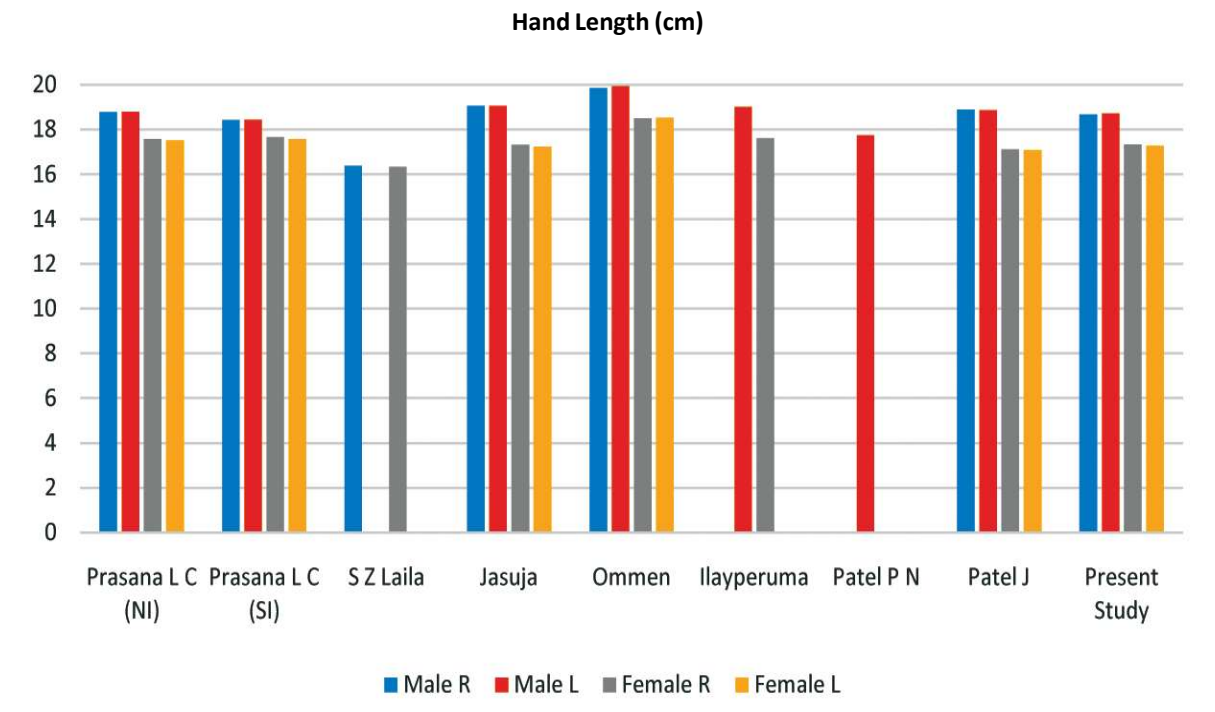


Fig. 5 : Comparison of Hand length



Conclusion

In this following inferences can be deduced

Hand length is highly correlated with middle dfinger length.

Middle finger length is positively correlated with both hand length and height of person.

Multiple correlation regression equation gives better predictive value for height.

Following data and equations can be useful for forensic purpose and in designing of instruments or in ergonomics.

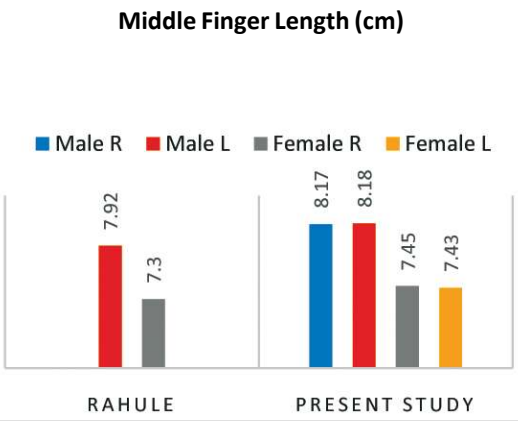
Table 5 : Comparison of Height (cm)

S.No	Name of the author	Sex	Min. Stature	Max. Stature	Mean	± SD	± SE
1	SZ Laila[5]	-	-	-	156.02	6.13	-
2	Jasuja[3] (2003)	Male	166.2	185.6	175.2	5.24	0.957
		Female	152	167.9	159.7	5.17	0.945
3	Patel J[8]	Male	-	-	175.95	5.91	-
		Female	-	-	160.86	5.6	-
4	Danborno B[11]	Male	-	-	173.73	7.13	-
		Female	-	-	160	6.22	-
5	Ilayperuma[4]	Male	-	-	170.14	5.22	-
		Female	-	-	157.55	5.75	-
6	Rahule[7]	Male	157	192	169.97	5.71	
		Female	139	167	154.2	7.15	
7	Srivastava[12]	Male	-	-	170.9	-	0.371
		Female	-	-	156.21	-	0.49
8	Present Study (2014)	Male	147	193.04	171.49	7.56	0.66
		Female	124	180.34	157.98	7.59	0.66

Table 6 : Comparison of Middle Finger length (cm)

Sr. No.	Authors	Measurements	Sex	Side	Min	. Max	Mean	± SD	± SE
1	Rahule	Middle Finger Length	Male	-	7.1	9.5	7.92	0.42	-
			Female	-	6	8.4	7.3	0.55	-
2	Present Study (2014)	Middle Finger Length	Male	Right	7	9.8	8.17	0.46	0.043
				Left	7	9.8	8.18	0.46	0.043
			Female	Right	6.2	9.3	7.45	0.55	0.044
				Left	6.2	9.2	7.43	0.54	0.042

Fig. 6 : Comparison of middle finger length



References

1. A K Datta; essentials of Human Anatomy; vol 3; 4th Ed, 2009; p:1
2. Olasunkanmi Salami ISMAILA,Anthropometric Data of Hand, Foot and Ear of University Students in Nigeria,Leonardo Journal of Sciences ISSN 1583-0233 Issue 15, July-December 2009 p. 15-20
3. Dr. O.P.Jasuja, G.Singh,ESTIMATION OF STATURE FROM HAND AND PHALANGE LENGTH, Journal of Indian Association of Forensic Medicine, 2004; 26(3): 100-106
4. IsuraniIlayperuma ,GananandaNanayakkara , NadeekaPalahepitiya, Prediction of personal stature based on the hand length. *Galle Medical Journal, Vol 14: No. 1, September 2009 P:15-18.*
5. SyedaZamilaHasanLaila, Roxana Ferdousi, ABM Nurunnobi, ATM Shafiqul Islam, SyedaZamila Hosen Holy , FarzanaYesmin; Anthropometric Measurements of the hand length and their correlation with the Stature of Bengali adult Muslim females; Bangladesh Journal of Anatomy January 2009, Vol. 7 No. 1 pp. 10-13.
6. AnithaOommen*, AvinashMainker* and Tom Oommen**, A Study of the Correlation Between Hand Length And Foot Length In Humans; J.Anat.Soc. India (2005), 54 (2) 1-9.
7. Rahule AS, ShekharRao B, MohdSaleem, Mohammed Shakeel Mohammed Bashir,Ajay Khade, MD Irfanuddin, Phani Chandra Y* A Study of Correlation between Middle Finger Length and Height in a Tribal District Population of India; J Cont Med A Dent Sept-Dec 2013 Volume 1 Issue 1 p 8-12.
8. Jitendra P Patel, Bharat G Patel, Ritesh K Shah, Naimish R Bhojak, Jalpa N Desai, I/C. NHL Journal of Medical Sciences/Jan 2014/Vol 3/ Issue 1 p: 41 - 44 .
9. Patel PN ,Tanna JA, Kalele SD, Correlation between Hand Length and Various Anthropometric Parameters *International Journal of Medical Toxicology and Forensic Medicine*. 2012;2(2):61-63.
10. Prasanna LC, and Vinay Kumar; Prediction of Stature and Sex by Hand Dimension-A Statistical Analysis in North and South Indians of Same Age Group; RRJMHS | Volume 3 | Issue 2 | April - June, 2014 p: 96-99
11. Danborno B, Eulko A: Sexual Dimorphism in Hand and Foot Length Indices, Strature ratio and relationship to Height in Nigerians; The Internet Journal of Forensic Science 2008: 3: 1-6.
12. Ankit Srivastava and Vijay Kumar Yadav; Reconstruction of strature using hand and foot dimensions among Indian population; International Journal of Engineering Sciences and Emerging Technologies, Feb 2014. Vol 6, issue 1; p: 400 – 404.

Indian Journal of Anatomy

Library Recommendation Form

If you would like to recommend this journal to your library, simply complete the form below and return it to us. Please type or print the information clearly. We will forward a sample copy to your library, along with this recommendation card.

Please send a sample copy to:

Name of Librarian

Library

Address of Library

Recommended by:

Your Name/ Title

Department

Address

Dear Librarian,

I would like to recommend that your library subscribe to the **Indian Journal of Anatomy**. I believe the major future uses of the journal for your library would be:

1. As useful information for members of my specialty.
2. As an excellent research aid.
3. As an invaluable student resource.
4. **I have a personal subscription and understand and appreciate the value an institutional subscription would mean to our staff.**
5. Other

Should the journal you're reading right now be a part of your University or institution's library? To have a free sample sent to your librarian, simply fill out and mail this today!

Stock Manager

Red Flower Publication Pvt. Ltd.

48/41-42, DSIDC, Pocket-II, Mayur Vihar, Phase-I

Delhi - 110 091 (India)

Tel: 91-11-22754205, 45796900, Fax: 91-11-22754205

E-mail: redflowerppl@gmail.com, redflowerppl@vsnl.net

Website: www.rfppl.co.in

Review Article

Indian Journal of Anatomy
Volume 3 Number 4, October - December 2014

The Bivalve Nervous System and its Relevance for the Physiology of Reproduction

Sukanlaya Tantiwisawaruji*, Eduardo Rocha, Uthaiwan Kovitvadhi***, Maria J. Rocha******

Abstract

Bivalves are widespread invertebrates that are mostly marine and benthic, with great impacts in the aquatic systems food chains. Their soft body is laterally compressed and covered with a hard shell, often having bilateral symmetry. Strong adductor muscles help in the shell movement. Various species are used as bioindicators of environmental quality. Many, such as mussels, clams, scallops, or oysters, are heavily harvested/reared for human consumption. Bivalves availability, adaptability and simple anatomy make them attractive for both fundamental and applied research. One particular target for such studies is the nervous system. It is typically made of a central nervous system holding three types of ganglia (cerebral, pedal, visceral), organized into an outer neuron- and glia-rich cortex and an inner axon-rich medulla. Nerves interconnect the ganglia as well as these and peripheral nervous system components, made of sensorial structures such as eyes (mantle, tentacles), and osphradia (gills) and statocysts (foot); They are involved in photoreception or are mechano or chemoreceptors. Among other roles, the nervous system governs reproduction, via influences in the sexual development, gametogenesis, fertilization and spawning. Such modelling is via neurotransmitters and neurohormones, interplaying with direct/ indirect impacts of biotic (*eg*, food abundance) and abiotic (*eg*, temperature, pH, salinity) factors. We know now that many pollutants can disrupt the nervous system and gonads and their poorly known interaction. Knowing the nervous system functional morphology is critical to understand such disruptions and foreseen reproductive consequences. Accordingly, this work offers a systematic overview about the bivalve nervous system and related reproductive events.

Keywords: Anatomy; Histology; Bivalves; Nervous system; Ganglia; Neurons; Glial cells; Neurocytology; Neurophysiology; Reproduction.

Author's Affiliation: *PhD Student, King Mongkut's University of Technology Thonburi (KMUTT), Bangkok 10140, Thailand. Institute of Biomedical Sciences Abel Salazar (ICBAS), University of Porto (U.Porto), 4050-313, Porto, Portugal. CIIMAR/CIMAR - Interdisciplinary Centre of Marine and Environmental Research, U.Porto, 4050-123, Porto, Portugal., **Full Professor, Institute of Biomedical Sciences Abel Salazar (ICBAS), University of Porto (U.Porto), 4050-313, Porto, Portugal. CIIMAR/CIMAR - Interdisciplinary Centre of Marine and Environmental Research, U.Porto, 4050-123, Porto, Portugal., ***Associate Professor, Department of Zoology, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand., ****Associate Professor, Superior Institute of Health Sciences-North (ISCS-N), 4585-116 Gandra-Paredes, Portugal. Institute of Biomedical Sciences Abel Salazar (ICBAS), University of Porto (U.Porto), 4050-313, Porto, Portugal. CIIMAR/CIMAR - Interdisciplinary Centre of Marine and Environmental Research, U.Porto, 4050-123, Porto, Portugal.

Corresponding Author: Eduardo Rocha, Full Professor, Laboratory of Histology and Embryology, Department of Microscopy, Institute of Biomedical Sciences Abel Salazar (ICBAS), University of Porto (U.Porto), Rua de Jorge Viterbo Ferreira n.º 228, 4050-313 Porto, Portugal.

E-mail: erocha@icbas.up.pt

Introduction

In almost all metazoans, the coordination is accomplished by two main mechanisms, hormones and nervous system signals. These two central systems interact with each other to maintain the homeostasis of animals and to respond appropriate information to the environmental stimulus [1-2]. In addition to these basic vital functions, the nervous systems of higher organisms are able to perceive and react to a greater range of environmental stimuli in intricate and varied way including responsible for feeling, thinking, and learning [3]. In vertebrates there are more complicated components of the nervous system. Anatomically, there are two systems: the central nervous system (CNS) and the peripheral nervous system (PNS). CNS consists of brain and spinal cord. The PNS comprises the somatic and autonomic nervous systems. Somatic afferents carry sensory information from the skin, muscle, and joints

to the CNS, while motor efferent nerves innervate skeletal muscle to cause the movement contraction. [4] The autonomic nervous system can be thought of as a motor system for visceral organs, because it projects to these organs to innervate and control the function of smooth muscle, cardiac muscle, endocrine, and exocrine glands. The autonomic nervous system is typically further divided anatomically and functionally into the sympathetic and parasympathetic subdivisions. [2, 4, 5]

In lower invertebrates of the animal kingdom, like Coelenterates or Cnidarians, the nervous system consist of specialized nerve cells of ectoderm called nerve net that consists of sensory and muscle cells diffusely distributed. [6, 7] The most highly evolved groups, like flatworms, show the first real CNS because their sensory cells are grouped into special anatomical collection forming a nerve ring or ganglia organized in the bilaterally symmetrical longitudinal body axis as nerve cords. Their ganglia can assume a segment-like structure as a result of the more or less regular array of cross-connections innervating the whole body. [8] In the head region, there are specialized structures, such as primitive "eye or ocelli". These structures are also be found in annelids, in which in the anterior end there is a distinct brain and segmented body plan, with ganglia organized into a ladder-like chain in each segment. [9] The dorsal brain is connected to the ventral chain of segmental ganglia via circumesophageal connectives. Each segmental ganglion, which typically is said to consist of about 1000 neurons, is organized in a bilaterally symmetrical way. Both halves are linked to one another by commissures and to neighboring ganglia by connectives. Peripheral nerves, typically three pairs, projects from each ganglion and innervate the segmental body wall. [10] All ganglia have a structure which is characteristic for higher invertebrates; neurons within cortex and the neuronal processes (dendrites and axons) lie in a neuropil in the core of the ganglion. In some annelids, distinctive giant neurons occur, and these play an important role in fast escape responses. [11] In some species the structure of optic ganglia is formed. [12, 13]

In arthropods, however, the body organization is different from that of annelids with articulated appendages and the fusion of originally unitary, metameric segments into the functional entities comprising the head, thorax, and abdomen. For such insects and crustaceans, their head region tends to form a complex brain consisting of extensively fused cerebral ganglia. These are often associated with the processing of information from specialized sensory organs, for example, a protocerebrum of insects, which receives visual sensory input from both compound eyes and from the simple ocelli, a deutocerebrum which receives sensory input from the antennae, and a tritocerebrum which receives input from the head surface. [14] These brain structures together contain about 90% of the neurons in the central nervous system, which in the larger crustaceans sum about one million nerve cells. In the higher arthropods, there are brain regions which consist of associative neuropil centres, cell body regions, and aggregates of neurosecretory cells. [15, 16] The requirement for accurate motor control of the articulated body appendages, especially the thoracic legs, has led to an increasing specialization of the ventral segmental ganglia. [17] There are the thoracic ganglia typically containing more interneurons, efferent projecting motor neurons and afferent sensory fibers than the abdominal ganglion. The latter, often associated with specialized structures, are located in the posterior end of the animal. In addition, there is a tendency toward fusion of the segmental ganglia into fewer (in some cases single) ganglia. [18] One such ganglion, the subesophageal, it is formed by several ganglia and controls the mouthparts – this is generally found enclosed in the head capsule. [19] The segmental specializations of the arthropod nervous system allow complex motor activity to be generated. This includes flying, running, jumping, manipulation, and sound production. [12, 18]

In molluscs, there are variations in the organization of the nervous system. In order to get sensations they have a collection of neurons in the ventral cord which are called ganglia. The basic organization of their CNS comprises about five pairs of ganglia which are arranged around the gut, normally near the head, and are linked to one another by connectives and commissures. It is possible to distinguish cerebral, buccal, pleural, pedal, and abdominal ganglia. [13, 20] The basic organizational plan can vary significantly among individual molluscan species, to the extent that the various ganglia can change their position and even fuse with one another. [12, 13, 20] In Gastropoda, Scaphopoda, Polyplacophora, Monoplacophora (slow-moving animals) and Cephalopoda (active predatory lifestyle), there is cephalisation. [7, 11, 21] There are numerous studies on the nervous system of the gastropod mollusc *Aphysia californica*, which is an animal model for the neurobiologists' study of behaviours, namely learning and memory. [22, 23] In bivalves, such as, clams, mussels, and scallops, there is bilateral symmetry and soft body. They have an interesting simple model of CNS, recognized as very useful for studies ranging from neurobiochemistry to neurophysiology. [7, 24, 25]

However, little seems to be known about the detailed anatomy of components in the bivalve nervous system. This Chapter reviews two major parts in bivalves. The first concerns the structure and function of nervous system. The second describes the neural control of reproduction.

General morphology and functions of nervous system in bivalves

Knowledge about the morphology and functioning of central nervous system in bivalves is still somewhat scarce and needing further study. The reasons for this limitation are varied. The histology, though studied to a certain extent, is different from that of vertebrates; most of the available forms are small, and the few experimental work has been performed using methods fruitful in vertebrates but, possibly, inadequate or insufficient for bivalves. A great feature of the bivalve nervous system is the small number of neuronal elements within ganglia and that contribute to the peripheral tissue. [20, 26] This makes possible a type of analysis that is difficult to achieve in vertebrates. Also, interesting direct correlations between the size of the ganglia and their function can be disclosed in bivalves.

The central nervous system

Anatomy of the ganglia

The basic plan of organization of all bivalves nervous system is bilaterally symmetric which each half body segment possessing a ganglion. In typical bivalves, they consist of three pairs of ganglia: cerebropleural (commonly called as cerebral), visceral and pedal; along with two pairs of long nerve cords. Both cerebral ganglia are interconnected to visceral and pedal ganglia by bilaterally running nerve cords. Each ganglion gives rise to nerve fibers that supply the organs and tissues in close proximity. [24, 26, 28] For instance, the cerebral ganglia innervate labial palps, anterior adductor muscle, anterior part of the mantle, and sensory organs, including statocysts (equilibrium organs) and osphradia (a chemo-mechanical sense organ). [29] The visceral ganglion innervates the gills, heart, posterior adductor muscle, posterior part of the mantle, siphons, and sensory organs in the mantle. [30] As in other bivalve species, the visceral ganglion of *Venus verrucosa* comes from the fusion of two original ganglia, thus showing bilateral symmetry; pairs of symmetrical nerves emerge from each pole and diverge. Lastly, the pedal ganglion, as the name indicates, innervates the foot. [28, 31, 32]

Cerebral ganglia

In most bivalves, the paired cerebral ganglia are well separated from each other (left and right) and they are usually triangular in shape, with the color varying from milky white to bright red. These ganglia are situated between the base of the labial palps and the first esophageal subdivision of the digestive tract, being shortly cross-connected by a commissure arching over the esophagus, as well as, longitudinal linked between pedal and visceral by connectives. In reality, they are formed by fusion of the cerebral and pleural ganglia around the anterior part, and that is why they are commonly referred as cerebropleural ganglia or cerebral ganglia in the literature [20, 32]; and herein we shall use the latter term henceforth for consistency. From each cerebral ganglion not only the principal two pair of nerves cords lead toward the posterior of the animal: one, cerebro-pedal connectives that extend posterior and ventrally to the pedal ganglia in the foot; another, cerebro-visceral connectives, running directly back from the cerebral ganglia to the visceral ganglion, which is located on the surface of the posterior adductor muscle. But, there are also the pallial nerves innervating the labial palp, anterior adductor muscle, gill [33], and part of mantle margin, as well as the statocysts and osphradia. In the absence of cephalic sense organs the cerebral ganglia are weakly developed and small. [33] In snails, the central ganglia are more concentrated and the visceral loop is so short that all of the principal ganglia are in the anterior nerve ring above the esophagus. [20, 21, 34]

Pedal ganglia

In general bivalves, the pedal ganglia is positioned below the esophagus and is anterior to the base of the foot. They have the same type of coloration but are larger than the cerebral ganglia and more rounded in appearance. The pedal commissures are rare; in most forms the right and left ganglia have met together in the middle line. Each ganglia extend the following nerves: 1) the pedal nerve, which innervates the foot, originates from the ventral posterior surface; 2) in genus *Mytilus*, the ventral byssus retractor nerve, innervating the byssus organ and muscle and arising from the posterior ventral side of the ganglion; 3) the dorsal byssus retractor nerve, which also innervates the upper byssus muscles arise from the posterior dorsal of the ganglion. In *Crassostrea virginica*, there are as well no pedal ganglia in line with the lack of a foot for moving. [24, 32, 35]

Visceral ganglia

In typical bivalves the visceral ganglion is the largest ganglia, being derived from the fusion of two original ganglia. Visceral ganglia either appear as "rounded triangles" or else having multiple lobules, with milky white to bright red in colour at the ventral end of the visceral mass, on the anteroventral border next to adductor muscle. The visceral ganglia are much larger than the cerebral and nerves emanating from it innervate the mantle, gills, intestine, anus, skin, posterior part of the genital apparatus, kidney, the main digestive gland and posterior adductor muscle. [32-36] In addition to their usual autonomic functions, the visceral ganglia also receive sensory inputs from the sensory tentacles of the mantle. The tentacles are photoreceptive, mechanoreceptive, and even chemoreceptive organs. [24, 32] It is of interest to note that the distribution of the nerves which originate from the visceral ganglia is not always identical for each ganglion. Processes could be seen to extend from nerve cell bodies. Fibres could be seen in the cerebro-visceral connective and in the origin of the branchial nerve. [36] The large white visceral ganglion can be revealed by opening the exhalant chamber and cloaca and looking between the pyloric process and the posterior adductor muscle. [30, 37, 38]

Histology of the ganglia

Irrespective of the ganglia types, they typically consist of three layers, an outermost perineurium, the outer cortex and the inner medulla, which can be called neuropil. [20, 39] Accordingly, the typical structural organization of the ganglia , bivalves like those of most invertebrates, consist of a multilayered rind of neuronal cell bodies which send their processes to a central core, are sheathed by a connective tissue perineurium and contain two types of cells: nerve cells (neurons) and glial cells.[13, 20]

Perineurium

Ultrastructural analysis of the *V. verrucosa* ganglia shows — from the ganglion periphery the perineurium — a limiting envelope formed by a sheath of connective tissue that consists of collagen fibers and fibroblasts; they are arranged in a loose three-dimensional network, alternating with sheaths of dense microfilamentous material with the appearance of a basal lamina surrounding the ganglia. [36] As for its function, the perineurium is likely to provide not only a protective envelope, but also a permeability barrier, which may be particularly important in bivalve ganglia which probably lack a glial blood-brain barrier. [13, 20] But the perineurium in vertebrates is different from that in invertebrates, because it is a concentric layer of bundled nerves that it is a protective layer of connective tissue located around nerves in the body and the internal organs. Indeed, it is composed of concentric layers of connective tissue that form a protective sheath around bundles of nerve fibers. This structure is a transparent tube-shaped layer that is easily pulled away from the bundled nerves. Perineurium nerve coverings are a part of the peripheral nervous system (PNS), which is responsible for transmitting messages from the central nervous system (CNS) in the brain to the effectors, like arms, legs, and internal organs. [2]

The cortical part of ganglia (cortex)

The cortex, a multilayered area of neuron and satellite glial cells in *V. verrucosa* [36], is to be the complex network centre of neuronal cell bodies and glial cells. The cortex is not only involved in the control of many internal, homeostatic regulatory processes, but also in the production of complex behaviours. Many of nerve cell bodies located in the cortex were radially oriented and closely associated with the connective tissue sheath. Many of the neurons send their axons into the neuropil ganglion (inner) zone.[40]

Medulla or neuropil region

As previous mention, in the most invertebrate ganglia such as arthropods and annelids, the cell bodies of neurons occur in a thin rind on the periphery of the ganglion, and the core that contains axons and dendrites is called the neuropil, a ganglionic core containing the axonal processes of the cortical neurons in *V. verrucosa*. [36] These nerve cell bodies appeared to be extensively innervated, as indicated by the specific staining of endings on their surface their process of the nerve cell body tapered as it extended from the body. The neuropil region has a fibre organization of axons in the nerve tracts that form clustered areas of complex synapses, i.e., glomeruli. [20, 37]

Ganglionic structure follows a common pattern in virtually all invertebrates, with an outer rind of neuronal somata surrounding an inner core of axons and dendrites. The somata are clustered in groups. The axonal processes of motor neurons leave the ganglion through the lateral nerves to innervate their targets in the periphery (often muscles). Most motor neurons have just one axon leaving the ganglion, but a few have axons in several nerves that innervate

different targets. In this way a single motor neuron can exert coordinated control over sets of muscles that need to act together. Individual muscles are generally innervated by just one or a few excitatory motor neurons. [13, 20]

Neurons and glial cells (ganglionic cells)

There is no doubt that in all bivalves the number of central neurons is smaller if compared to more complex animals. Notwithstanding, each neuron has a specific and often complicated task to perform which involves receiving and making many synaptic connections.[41, 42] In certain instances, differences between the pair of neurons in each half of the central nervous system are slight, so that one can replace the other to a considerable extent. But in many other cases the loss of one fibre must involve considerable loss of function, which may be mitigated to a certain extent by the overlapping fields of different neurons. The nervous system also contains cells that surround, nourish, and support the neurons and their process, and these are called glial cells. [40]

Nerve cells or neurons

As in most invertebrates, unipolar neurons predominate, even though a few bipolar and even multipolar nerve cells have been described. [13, 20, 43] Neuronal cell bodies have overall ultrastructural features similar to those of most vertebrate and invertebrate neuron. They contain a pale round or oval nucleus with one or more prominent nucleoli. The cytoplasm is rich in granular and agranular endoplasmic reticulum, free ribosomes, mitochondria and glycogen deposits. Some mitochondria have a paracrystalline structure, similar to that found in the neurons of *Spisula solidissima* [32, 44], which may be related to the accumulation of proteins and lipid; as it is known to occur in a variety of vertebrate and invertebrate cells. Microtubules and microfilaments are bare. Golgi complexes are numerous and developed, being formed by long cured cisternae filled with finely granular electron-opaque material and by vesicular profiles of variable size and electron density. In most cell bodies, dense core vesicles are an important component and can be found in large amounts dispersed in the cytoplasm. They display a great variability of size, shape and electron-opacity and represent the only distinctive feature of the neuron, which are comparable in other ultrastructural respects. [37, 45]

Most neuronal bodies are in the cortex and close to the perineurium sheath of the ganglia. There are also the beginnings of the nerves fibres that are made of axons (i.e., neurites in unipolar neurons) and eventual dendrites. [46] Pigments can also be found within neuron, namely as granules designated by cytosomes or lipochondria, exactly alike described in gastropods. [20, 37, 47] The cytoplasmic membranes of neuronal cell bodies, which are in extensive reciprocal contact, do not show particular specializations, except for the presence of subsurface cisternae in peripheral neurons of *S. solidissima*. [44]

The neuronal cell process originates from a large, cone-shaped extension of the soma which gradually taper. The cytoplasm contains microtubules, neurofilaments, mitochondria and vesicles displaying the same ultrastructural heterogeneity as those in the cell bodies. The ganglionic core is formed by a complex network of processes of different diameters. Nerve processes containing cytoskeletal elements are intermingled with others filled with vesicles. Tracts are formed by wider axons of passage, while non-glomerular neuropil contains finer processes which arborise and establish synaptic contacts. [20] Different types of neurons can be identified from their branched process pattern and in terms of function, and so they can be grouped into three basic categories: a) neurons with specialized endings that respond to energy from the environment are called sensory neurons; b) neurons that have axons terminating on muscle fibers are called motor neurons c) all other neurons, that are interneurons. [1, 21, 48]

The majority of synaptic contacts occur in the neuropil between nerve processes, even if rare, axomatic synapses have also been recognized within the cortex. The presynaptic sides can be identified both the presence of neurotransmitter vesicles and of electron dense areas collate to the membrane. In these synaptic areas, organelles such as mitochondria and cytoskeleton elements are sparse. Post synaptic sites are simpler, being the most significant feature the unevenness of the membrane. The synaptic space (cleft) typically does not vary in width (H" 20 nm) across the synapse. Despite this key features, more than one type of synaptic characteristics may occur. For instance, in the genus *Mytilus* there are synapses with vesicles that only have a lucid content while other have vesicles having either dense or clear cores. In addition to the vesicle discharges at synapses, it is accepted that neuromediators are released at non-synaptic sites; a process that is not exclusive of bivalves. More details on the above can be read elsewhere. [46, 49]

Glial cells

As in vertebrates, the glial cells of invertebrates have a vast array of structural and functional specializations. [50] They can be feature of the higher invertebrate groups like, the Arthropods, Annelids and Molluscs. Their location is around the neurons, especially at the nervous tissue interface. Glial cells have an oval nucleus with chromatin clumped in the periphery. Generally, two types of electron-dense, membrane-bound inclusions can be discerned: cytosome-like bodies and oval granules called gliosomes (450-650 nm in length and 250-350 nm in width). These later are a distinctive feature of glial cells in several bivalve species (and also gastropods). Their role in nervous activity appears to be necessary when the neurons become aggregated into ganglia. [13, 50, 52] In the *Mytilus edulis*, glial cells have an oval or indented nucleus with chromatin clumped in the periphery. Their cytoplasm is usually scanty but nevertheless contains microfilaments, mitochondria, cisternae of rough endoplasmic reticulum, free ribosomes, and small Golgi complexes.[53] Neuronal cell bodies in the cortex of the pedal ganglion are subdivided in clusters by septa formed by glial cell bodies and their processes, among which there is a system of intercellular channels, mainly evident in the subperineurial zone. In this region, even in well-fixed tissues, there are clusters of empty vesicular profiles of variable size, which seem to bud off from glial processes: the nature of dark glial cells characterized by a dense cytoplasm, which are present in the deepest regions of the cortex and in the neuropil. Glial cells appear less frequently in the ganglion central fiber core, being completely absent from wide neuropil regions. [20, 51]

The peripheral nervous system

The peripheral nervous system of bivalve is made up of sensory structures regulated through the lateral nerves. The organs are usually tentacles and most are typically mechanoreceptors and chemoreceptors. The sensory organs of bivalves are not well developed, and are largely a function of the posterior mantle margins. In scallops have complex eyes with a lens and retina, but most other bivalves have much simple eye or ocelli. In Septibranchs, the inhalant siphon is surrounded by vibration-sensitive tentacles for detecting prey.[7, 54]

Primary ciliary receptors

In bivalves, three types of ciliated sensory receptors were described. [55, 57] The most common consists of 35-40 nonmotile cilia on a cluster of four to six sensory neurons, apparently mechanoreceptors associated with a pair of glandular cells. The second type, a monociliary receptor, has a long, stiff kinocilium surrounded at the base by a corolla of nine short, club-shaped microvilli. The third type consists of 17-20 nonmotile cilia in a circle on a single sensory neuron that distally envelops a gland cell. These structures work as mechanoreceptors and can be seen in the tentacles of the scallop *Placopecten magellanicus* [58], mantle edge of *Donax serra* and *Donax sordidus* and on the siphon of *Macoma balthica*. [56]

Ocelli (eye spots)

Bivalves have two types of eyes: paired cerebral eyes, as well illustrated in the veliger (the planktonic larval stage) and adults of *M. edulis*, and pallial eyes. [32] The latter eyes are found on the siphons of *Cardium edule* and on the middle mantle fold of the *Pecten maximus*. [59] This organ is the light receptor, containing pigmented cells. In *M. edulis*, cerebral eyes appear as dark spots located at the bases of the first ctenidial filaments of the left and right inner demibranchs. Each ocellus is an open cup, and the retina is composed of sensory and pigment cells. Eyes in *P. magellanicus* are on the middle of the mantle skirt. [32] The photoreceptoral organelles are directed toward the incoming light. The sensory cell has a bulbous nuclear region, a slender cell process, and, apically, rhabdomeres, and, compared to the eye of genus *Pecten*, there are very few receptor cells. [59] In *Pecten maximus*, more than 60 eyes are located in the sensory fold of the mantle. [58] Each consists of a cornea, a large cellular lens, a distal and proximal retina, a reflecting argentea, and a layer of pigment cell around the eye. The lens cells contain few organelles and rest on a thick basal lamina. Beneath the lamina there are nerve fibres of the distal retinal cells that bear few microvilli among numerous cilia at their distal surface. The axon leaves the distal retinal cell from the side, passes up to the basal membrane, and joins other distal nerve fibers to form the optic nerve. There are glial supporting cells between the distal and the proximal retina, the cells of which face in the opposite direction from the distal cells. [58, 59]

Statocyst

In bivalves, paired statocysts are located in both dorsolateral sides of the pedal ganglia, and there are nerve connecting them to the cerebral ganglia. In the genus *Pecten*, each statocyst consists of a sac of hair cells and supporting cells. Inside the sac is a statolith

composed of crystals, and a static nerve extends from the sac and eventually connects to the cerebral ganglion. [60] Hair cells have kinocilia, microvilli at their distal ends, and one or more striated roots that pass deeply into the cell cytoplasm. They function to allow animal to maintain orientation. [32, 61]

Osphradium

The osphradium can detect incoming water as a chemo- or mechanoreceptor around the ctenidial axis, exhalent, and suprabranchial section of mantle cavity. In a number of bivalve species, osphradia have sensory processes, sensory cells, supporting cells, and innervation of the ridge by nerves from ventral ganglion. [29] The osphradium is an ancient sensory structure in Mollusca, and it is better developed in Gastropoda, where it is a strategically located chemo-mechanical organ in the pallial cavity. [32, 62]

Abdominal sense organs

Abdominal sense organs are situated on the ventral surface of the posterior adductor muscles in bivalves. [32] The sensory epithelium is tall and consists of two predominant cell types, electron-dense supporting cells with microvilli only, pigment granules and oval distal nuclei, and sensory cells with round proximal nuclei and electron-lucent cytoplasm. The narrow sensory processes always are bunched and reach the surface bearing long stiff cilia. Surrounding the cilium is nine 'stereomicrovilli' forming a basal plate in connection with the basal body. In the prosobranch *Nucula sulcata* there is the so-called Stempell's organ, a tube-like sense organ, situated immediately dorsal to the anterior adductor muscle. Collar receptors in the sensory portion of the organ indicated a mechanoreceptive function. [32]

The cellular components of an invertebrate nervous system include: sensory neurons, which convert physical variables (e.g., light level or muscle force) into electrical signals; motor neurons, which make synapses with muscles or other effector organs (e.g., light-producing organs, glands); interneurons, which transmit information between other neurons; and glial cells, which are electrically excitable, that influence the ionic environment surrounding neurons and the transmission of signals between them. [13] The transport of signalling of neurotransmitters is considered to be a major function of ganglia in most bivalves division of the ganglia. The central nervous system of bivalves have neurons that contain the biogenic amines dopamine (DA), norephinephrine (NE) and serotonin (5-HT), each type might inhibit the synthesis of the other transmitters.

Neuroactive substances

There are various techniques to study in nervous tissue of bivalves, and one of the important technique is immunocytochemistry, which for instance characterized the neurons containing neuroactive substances in *M. edulis*.[46]

Serotonin or 5-hydroxytrytamine (5-HT)

5-HT is found in the central nervous system of vertebrates and invertebrates. [63] It is thought as the key neurotransmitter that control reproductive process of many invertebrates, such as the crustacean *Macrobrachium rosenbergii*. [64] In *M. edulis*, serotonin immunoreactive neurons were seen in light microscopic immmunocytochemical studies. Most often, those neurons are unipolar (8.5-25 μm) and very numerous both in the pedal and the cerebral ganglia. [65] Moreover, a great number of labelled nerve processes were shown in the ganglionic cores, in the connectives and in the nerves. In the bivalves *Anodonta cygnea* and *Mactra stultorum*, auto radiographic studies indicated that there is a selective uptake of 3H5-HT by ganglionic nerve processes containing dense core vesicles. The neuropil of the pedal ganglia has small dopamine-containing neurons closely associated with it. Situated ventrally in the pedal ganglia is a large group of 5HT-containing neurons. Both dopamine and 5-HT are present in the cells at the junction of the visceral and right parietal ganglia, and that dopamine and 5-HT varicosities are present in the neuropil of the pedal ganglia in molluscs. [63]

Neuropeptides

Neurons immunoreactive for gamma-aminobutyric acid (GABA) have been verified in all the ganglia using an antibody directed against the amino acid itself. [66] GABA immunoreactive neurons are represented more in the pedal and cerebral ganglia than in the visceral ganglia, but are less numerous than neurons displaying 5-HT-positivity. For the majority, GABA-positive neurons are small, unipolar (10 μm in diameter), the exceptions being represented by a few small bipolar and multipolar cells present almost exclusively in the pedal ganglia. [48] In these latter there are also two pairs of bilaterally symmetric, large (30 μm in

diameter) multipolar neurons with long processes projecting widely throughout the neuropil. Immunoreactive processes form networks in the ganglionic cores and run in all the connectives and nerves; even so, GABAergic fibers are very rare in the foot. [48] Whether peptide releases occur at synaptic contacts remains to be fully elucidated, as synaptic terminals positive to neuropeptides have not yet been recognized. In addition to the substances above-mentioned, there is physiological and pharmacological evidence for the presence of other peptides, both in the central and peripheral nervous system, such as the case of FMRFamide (Phe-Met-Arg-Phe-NH2). [43]

Acetylcholine (Ach)

Acetylcholine has long been recognized as a neurotransmitter. In most bivalves Ach acts as an inhibitory neurotransmitter whereas in some it may have an excitatory role. Ach actions can be even inconsistent within a species. Ach has, therefore, a wide variety of effects, e.g., on the heart where it is a cardioinhibitory neurotransmitter. [67]

Dopamine

Dopamine is widely distributed in the invertebrate nervous system and has a diverse effect of reproduction in bivalves. [68] Dopamine was shown to inhibit spawning activity in serotonin-treated *Dreissena polymorpha* mussels, indicating that spawning activity is stimulated by serotonin but negatively controlled by dopamine (i.e. dopamine is linked to gametogenesis rather than spawning and fertilization) [69]. In the gonads of *Mizuhopecten yessoensis*, dopamine acts both as a neurotransmitter and neurohormone to rise the levels of cAMP, that seem to play a regulatory role in the reproduction. [70] This does not mean that dopamin have actions restricted to reproduction, exemplified by its role in the contro of ciliary beating as elegantely demonstrated in *C. virginica*. [42]

Mechanisms of neuronal transmission

Knowing that nerve impulses were mediated by chemical neurotransmitters, it became possible to isolate the inhibitory and excitatory effects of nerve stimulation and to identify the probable neurotransmitter substances.

The action potential

Just as a quick reminder, a basic function of most neurons is ability to produce nerve impulses or action potentials along the cell membrane. Potential differences cross the membrane known as the membrane potential. In the resting potential membrane, it is approximately -65 mV. When the membrane potential is raised enough to reach the threshold result in voltage-gated, sodium channels open up and allowing Na+ to flow into the cell and depolarizing the membrane. This is an action potential (AP), the rapid depolarization is soon opposed by the closing of Na+ channels (stopping its influx from the exterior) and opening of K+ channels (allowing the efflux of K+, during both the repolarisation and hyperpolarization phases for restoring the resting potential). Finally, both Na+ and K+ channels close and the membrane potential return to resting stage and along the membrane is passively extended and excited adjacent areas to do the same step. The presynaptic terminal contains synaptic vesicles-packets containing a chemical neurotransmitter. The type of neurotransmitter varies depending on the neuron. [1-5]

Neurotransmitter activity

We know that there are different neuropeptides and that small-molecule transmitters exist in the neuron bivalves, including acetylcholine, monoamines, and amino acids. [71] For the events underpinning impulse conduction, the synapse plays a critical role in integrating activities of the nervous system. This synapse is one in which transmission is chemically mediated, i.e., a substance liberated from the nerve ending of one cell brings about excitation in the plasma membrane of the next. In many cases acetylcholine fulfils this function just as it does in the classical myoneural junction. In other instances norepinephrine plays a similar role, although in these cases some structural differences in the synapse appear. Indeed, specialized low-resistance connections exist, coupling the pre and postsynaptic neurons and resulting in extremely rapid transmission. Finally, in all cases in which electrical transmission has been seen a particular structural type of intercellular junction has also been present. [1, 20]

Neural modulation of the physiology of the reproduction in bivalves

Many substances have been candidates as neurotransmitters in bivalves. Acetylcholine, 5-hydroxytryptamine, dopamine, and FMRF amide, they might be physiologically significant in a few species. Acetylcholine and 5-hydroxytryptamine are almost certainly neurotransmitter substances in the gonad whether or not any other neuroactive

endocrine substances are release at sites remote from the gonad. [1, 65] Bivalves possess large identifiable nerve cells in their ganglia, and some of these have been shown to be reproductive-regulatory. [72]

For example, in green lipped mussel, *Perna canaliculus*, neurons in the visceral ganglia of both male and female were characterized by immunohistochemical techniques, and found that there are immunoreactivity of anti-5HT and anti-DA in large type and anti-APGWamide in small type of neurons.[38] In the gastropod *Haliotis asinina*, which has a predictable spawning cycle, there are various neuropeptides secreted from anterior ganglia that play a regulatory role in reproduction, like APGWamide, myomodulin, and FMRamide. [73]

Morphological and physiological aspects of gonads and breeding cycles

Sexual differentiation

Gonochorism is the condition of most bivalves, with no external morphological differences between the sexes. [7, 74, 75] However, the presence of some hermaphrodites in wild populations was reported, e.g. in the form of oocytes within the normal testicular tissue (ovotestis), namely in individuals of *Scrobicularia plana*.[76, 77] Some species are naturally predominantly hermaphrodites, with distinct male and female portions of the gonad, like seen in scallop *Pecten maximus*; the mature gonad is divided into two areas: dorsal testis with white colour and ventral ovary with orange-red colour. [7, 78] In *Anadara broughtoni* (48.3-52.5 mm in size), gonads are present at sexual maturity and the sexes were reported as being separated. In *Anadara senilis* from Nigerian coast, studies on the sexuality concluded that it is a protandrous hermaphrodite (monoecious), with animals developing as males first and then changing to be females. [79]

Gametogenesis

Gametogenesis involves the production of gametes in the gonad that occupy a major portion of the visceral mass as in bivalves. Spermatogenesis and oogenesis is related to a period of reproductive cycle that is influenced by external environmental factors. Spermatogenesis occurrence located along the inner periphery of acinus. Spermatogonia are the first cells to become primary spermatocytes by mitotic divisions, later these cells undergo into meiosis to become secondary spermatocytes and spermatids, respectively, then following the differentiation of mature spermatids into spermatozoa without further cell divisions. [28, 32] As to oogenesis, the primary oogonia have potential to do repeated mitosis and in the process differentiate to secondary oogonia, which ingress in the meiotic process until stopping at the prophase stage of meiosis I — the completion of meiosis occurs at fertilisation. During oogenesis, the oocytes greatly increase in size by a process named vitellogenesis, which basically consists in the assemblage of lipids and some glycogen in the ooplasm. [7, 78]

Spawning

In most bivalves, there are various stimuli suggested as being importance in control the breeding cycle, like water temperature, pH range, tide, latitude, and food abundance. [75-80] Whilst extreme temperatures may inhibit spawning, these seem to be less limiting in warmer climates than in temperate waters. It is a widely suggested that in each species may occur only over a critical spawning period and also depending on the physiological condition of the animals and/or their geographical distribution. [81, 82] Generally, gametes are discharged into the mantle cavity and then into the environment by valve movements, relaxation of adductor muscles, enlargement of ostia, and increased ciliary action of the ctenidia [32-79] and are fertilized externally. Internal fertilization in some bivalves females collect sperm in the mantle cavity or gill chamber and then the developing larvae are brooded. The zygote continues develop in various larval forms (trochophore and veliger) up to reaching the juvenile stage. [32] Differences exist even in species of the same genera. For example, the major period of spawning of *Anadara granosa* in southern Europe is from July to October with a peak in August, and larvae can be found for over a two month period. [83] This is different from *A. senilis,* as it appeared that the major spawning period is in October, and some spawning of *A. gmnosa* probably takes place throughout the year. [79] But there are evidences of a peak period in between June and September. *In A. broughtoni* from Japan has spawning time in beginning of August to the end of September. [79]

Evidence for neurosecretory (neuroendocrine) substances involved in reproduction

Bivalve reproduction consists of many critical steps, beginning in nerve centres and ending in the gonads. The steps include sexual development, gametogenesis, fertilization and spawning. On the whole, sexual differentiation processes of bivalves are still in doubt but some aspects are gaining a better understanding. Serotonin, dopamine and sex

steroids are some agents that are involved in the sexual differentiation process. [84]

Monoamine oxidase (MAO) regulated by serotonin level is the main elimination pathway for monoamines such as dopamine, serotonin, octopamine and noradrenaline. The MAO activity could be induced by a variety of secondary amines in the environment and could likely modulate serotonin levels in nerve tissues and perhaps sex differentiation. For example, MAO activity in the nerve ganglia and gonad was shown to be induced with a concomitant decrease in serotonin and dopamine in mussels exposed for 90 day, 10 km downstream from a primary-treated municipal effluent plume. [85] Indolamines (serotonin and tryptomine) and catecholamines (i.e., dopamine and noradrenaline) are particular neurotransmitters involved in the integrated actions of neuronal populations that implicate at the sexual differentiation in bivalves.[86-87] The level of dopamine increases after injections of E2 in the sea scallop, but it dropped during active spawning period.[88] Moreover, dopamine was shown to inhibit spawning activity in serotonin-treated *D. polymorpha* mussels. [69] There has been a quest to locate the involved neurons. For instance, an immunohistochemical study was made in the green-lipped mussel, *Perna canaliculus*, using anti-sera raised against neuropeptides and neurotransmitters known to control reproduction and spawning. The authors concluded that there are neurons positive for serotonin (5-HT), dopamine (DA), APGWamide, and egg-laying hormone (ELH) within the visceral ganglia, despite not being able to prove the physiological functions in the control of the reproduction of the studied species. [38]

Many of the hormones in invertebrates are neurohormones, so they are produced by nerve cells. [89] As with conventional neurons, neurosecretory cells are able to receive signals from other neurons. However, unlike ordinary neurons that have cell-to-cell communication over short distances at synapses, neurosecretory cells ultimately release their product into an extracellular space that may be at some distance from the target cells. [89] In an organism with a circulatory system, the neurohormones are typically sent by the vascular route to their target. In contrast, in lower invertebrates that lack an organized circulatory system, the neurohormones apparently simply diffuse from the release site to the target. In molluscs, the neurosecretory cells and nerve cells in ganglia are described as endocrine cells producing neurohormones (dopamine, noradrenaline and serotonin). [89] In *V. verrucosa*, 5-HT was studied by immunohistochemistry, and it was found in serotonergic neurons that were located at a region of the cortex of the visceral ganglion, in serotonergic fibers at the root of branchial nerve, and along the walls of the ovarian follicles and also running between the seminiferous acini. [36] In *Lamelliden scorrianus,* two types of neurosecretory cells were observed on the dorsal surface of cerebropleural ganglia, which accumulate the neurosecretory material at low temperature. [90]

By all the above, it is logically possible to hypothesize that there is a large potential for xenobiotic endocrine disruption effects on the nervous system controlled reproduction.

Effects of endocrine-disrupting chemicals on bivalves

Endocrine-disrupting chemicals (EDCs) are substances that can interfere with the endocrine system of animals, being this simplistic definition subject to refinements.[91] EDCs are known for a wide range of chemical compounds, including, natural estrogen and synthetic hormones (ethynylestradiol), industrial chemicals (such as alkylphenols, bisphenol A, ethoxylates and tributyltin) and pesticides (*eg*, chlormephos and atrazine). [92-94] Evidence of the effects of these compounds has been presented in the majority of studies with fish, crustaceans, annelids and molluscs. [95, 97] Certain alarming concerns have been increased in human health of EDCs, such as decline in sperm quality, increase in the frequency of development abnormalities of the male reproductive tract, precocious puberty, and altered neuronal development. [98, 99]

Aquatic organisms are being subjected to contact with these substances because they are discharged into the water, and thus appear in rivers, estuaries and sea. [100] This lead to numerous studies on wildlife and consequently the interest on endocrine disruption of invertebrates is obtaining more attention. Nowadays there are facts pointing that bivalves seem to be affected by EDCs, as revealed by the appearance of oocytes in the testes (ovotestis-intersex) of the peppery furrow shell, *S. plana*, from the Avon Estuary, United Kingdom, where there was a likely source of estrogenic chemical from agriculture, and also in the Guadiana Estuary, in Portugal, where the presence of EDCs was thought to mainly derived from urban, industrial and agricultural discharges.[76, 77] In the freshwater mussel, *Elliptio complanata*, waterborne exposure to estrogenic compounds present in municipal effluents (and also direct exposures by injection), were able to

alter the metabolism of serotonin and dopamine (both players in the sexual differentiation), likely via E2 receptor-mediate pathway and serotonin receptors.[85] All these examples do show the current pertinence to address EDCs impacts over the nervous system of bivalves, and looking for the impacts of the gonadal maturation events.

References

1. Kay I. Introduction to Animal Physiology. Oxford: BIOS Scientific Publishers Ltd.; 1998.
2. Widmaier EP, Raff H, Strang KT. Human Physiology: The Mechanisms of Body Function. 9 ed. New York: The McGraw-Hill Companies; 2003.
3. Eisenstein EM. Review: Selecting a model system for neurobiological studies of learning and memory. Behav Brain Res. 1997; 82(2): 121-132.
4. Brodal P. The Central Nervous System. 4th ed. New York: Oxford University Press; 1992.
5. Rastogi SC. Essentials of Animal Physiology. 4th ed. New Delhi: New age international Ltd.; 2007.
6. Galliot B, Quiquand M, Ghila L, De Rosa R, Miljkovic-Licina M, Chera S. Origins of neurogenesis, a cnidarian view. Dev Biol. 2009; 332(1): 2-24.
7. Brusca RC, Brusca GJ. Invertebrates. 2nd ed. Massachusetts: Sinauer Associates, Inc.; 2003.
8. Kotikova EA, Raikova OI, Reuter M, Gustafsson MKS. The nervous and muscular systems in the free-living flatworm *Castrella truncata* (Rhabdocoela): an immunocytochemical and phalloidin fluorescence study. Tiss Cell. 2002; 34(5): 365-374.
9. Purschke G, Hessling R. Analysis of the central nervous system and sense organs in *Potamodrilus fluviatilis* (Annelida: Potamodrilidae). Zoolog Anz. 2002; 241: 19–35.
10. Orrha L, Muller MCM. Morphology of the nervous system of Polychaeta (Annelida). Hydrobiologia. 2005; 535(1): 79–111.
11. Moore J. An Introduction to the Invertebrates. 2nd ed. Cambridge: Cambridge University Press; 2006.
12. Reichert H. Introduction to Neurobilogy. 1st ed. Germany: University Press; 1992.
13. Matheson T. Encyclopedia of life sciences: Invertebrate nervous systems. Cambridge: Macmillan Publishers Ltd.; 2002.
14. Loesela R, Nässelb DR, Strausfelda NJ. Common design in a unique midline neuropil in the brains of arthropods. Arthropod Struct Dev. 2002; 31(1): 77-91.
15. Shiga S, Numata H. The Role of neurosecretory neurons in the pars intercerebralis and pars lateralis in reproductive diapause of the blowfly, *Protophormia terraenovae*. Naturwissenschaften. 2000; 87(3): 125-128.
16. Padmaja M, Deecaraman M, Jaganathbose MT. Study of neurosecretory cells in sand lobster *Thenus orientalis* of royapuram coast-chennai. World J Fish & Marine Sci. 2010; 2(2): 82-85.
17. Harzsch S, Glötzner J. An immunohistochemical study of structure and development of the nervous system in the brine shrimp *Artemia salina* Linnaeus, 1758 (Branchiopoda, Anostraca) with remarks on the evolution of the arthropod brain. Arthropod Struct Dev. 2002; 30(4): 251-270.
18. Kirsch R, Richter S. The nervous system of *Leptodora kindtii* (Branchiopoda, Cladocera) surveyed with confocal scanning microscopy (CLSM), including general remarks on the branchiopod neuromorphological ground pattern. Arthropod Struct Dev. 2007; 36(2): 143-156.
19. Whitington PM, Mayer G. The origins of the arthropod nervous system: Insights from the Onychophora. Arthropod Struct Dev. 2011; 40(3): 193-209.
20. Bullock TH. Mollusca: Pelecypoda and Scaphopoda. In: Bullock TH, Horridge GA, editors. Structure and function of the nervous systems of invertebrates. London: W. H. Freeman & Co; 1965. p. 1387-1431.
21. Chase R. Behavior and its neural control in gastropod Molluscs. Oxford: University Press; 2002.
22. Glanzman DL. Habituation in *Aplysia*: The Cheshire cat of neurobiology. Neurobiol Learn Mem. 2009; 92(2):147-154.
23. Croll RP. Catecholamine-containing cells in the central nervous system and periphery of *Aplysia californica*.J Comp Neurol. 2001; 441: 91-105.
24. Barnes RD. Invertebrate Zoology. 2nd ed. Toronto: W. B. Saunders Company; 1968.
25. Pani AK, Croll RP. Pharmacological analysis of monoamine synthesis and catabolism in the scallop, *Placopecten magellanicus*. Gen Pharmacol.1998; 31(1): 67–73.

26. Khanna DR, Yadav PR. Biology of Mollusca. New Delhi: Discovery Publishing House; 2004.

27. Pennak RW. Fresh-water invertebrates of the United States: Protozoa to Mollusca. 3rd ed. New York: John Wiley and Sons; 1989.

28. Gosling E. Bivalve Molluscs: Biology, Ecology and Culture. Oxford: Blackwell Publishing; 2004.

29. Beninger PG, Donval A, Le Pemmec M. The osphradium in *Placopocten magellanicus* and *Pecten maximus* (Bivalvia, Pectinidae): histology, ultrastructure, and implications for spawning synchronisation.Mar Biol. 1995; 123(1) : 121-129.

30. Kraus DW, Doeller JE, Smith PR. A physiological comparison of bivalve mollusc cerebro-visceral connectives with and without neurohemoglobin. I. ultrastructural and electrophysiological characteristics.Biol Bull. 1988; 174(1): 54-66.

31. Morton B. Feeding and digestive in Bivalvia. In: Saleuddin ASM, Wilbur KM, editors. The Mollusca. New York: Academic Press; 1983. p. 65-147.

32. Harrison WF, Kohn JA. Microscopic anatomy of invertebrates. New York: Wiley-Liss, Inc.; 1997.

33. Ruppert EE, Fox RS, Barnes RB. Invertebrate Zoology: A functional evolutionary approach. 7th ed. Belmont CA: Brooks Cole Thomson; 2004.

34. Kamble NA, Londhe SR. Copper sulphate induced neuronal histological changes in the freshwater snail *Bellamya bengalensis* (L). Bioscan. 2011; 6(2): 351-354.

35. Martin K, Huggins T, King C, Carroll MA, Catapane EJ. The neurotoxic effects of manganese on the dopaminergic innervation of the gill of the bivalve mollusc, *Crassostrea virginica.* Comp Biochem Physiol C: Toxicol Pharmacol. 2008; 148(2): 152-159.

36. Siniscalchi A, Cavallini S, Sonetti D, Sbrenna G, Capuano S, Barbin L, et al. Serotonergic neurotransmission in the bivalve *Venus verrucosa* (Veneridae): a neurochemical and immunohistochemical study of the visceral ganglion and gonads.Mar Biol. 2004; 144(6): 1205-1212.

37. Odiete WO. Fine-structure of the neurons in the mid-dorsal lobes of the visceral ganglion of the Lamellibranch mollusc *Scrobicularia plana* (da Costa). J Mollus Stud. 1978; 44: 305-321.

38. Mahmud S, Mladenov PV, Sheard P, Chakraborty SC. Characterization of neurons in the visceral ganglia of the green-lipped mussel (*Perna canaliculus*) using antibodies raised against neuropeptides and neurotransmitters. Bang J Anim Sci. 2008; 37 (1): 78 - 85.

39. Blankenship JE, Houck B. Nervous system (invertebrate). New York: McGraw-Hill Companies; 2008.

40. Laming PR, Kimelberg H, Robinsonc S, Salmd A, Hawrylakd N, Müller C , et al. Review: Neuronal–glial interactions and behaviour. Neurosci Bio behav Rev. 2000; 24(3): 295–340.

41. McLaughlin BJ, Howes EA. Structural connections between dense core vesicles in the central nervous system of *Anodonta cygnea* L. (Mollusca, Eulamellibranchia).Z Zellforsch. 1973; 144(1): 75-88.

42. Carroll MA , Catapane EJ. The nervous system control of lateral ciliary activity of the gill of the bivalve mollusc, *Crassostrea virginica.* Comp Biochem Physiol A Mol Integr Phsiol. 2007; 148(2): 445-450.

43. Henry M, Benlinmame N, Belhsen O, Jule Y, Mathieu M. Immunohistochemical localization of FMRFamide-containing neurons and nerve fibers in the ganglia and the gonad wall of the scallop, *Pecten maximus* (L). Neuropeptides. 1995; 28(2): 79-84.

44. Prior DJ, Lipton BH. An ultrastructural study of peripheral neurons and associated non-neural structures in the bivalve mollusc, *Spisula solidissima.*Tissue Cell. 1977; 9(2): 223-240.

45. Rosenbluth J. The visceral ganglion of *Aplysia californica.*Z Zellforsch. 1963; 60(2): 213-236.

46. Stefano GB. Neurobiology of *Mytilus edulis.* Manchester : Manchester University Press;1990.

47. Torska IV, Bilokrinitskyi VS, Burchinska LF, Genis YD. Properties of neurons of the central nervous system of the freshwater gastropod mollusc, *Planobis corneus.* Neurosci Behave Physiol. 1968; 14(4): 456-471.

48. Peter JS, Young D. Nerve cells and animal behaviour. 2nd ed. Cambridge: Cambridge University Press; 2003

49. Elekes K, Hiripi L, Nemcsók J. Ultrastructural effects of 6-hydroxy-dopamine and 5, 6-dihydroxytryptamine on the central nervous system of fresh-water mussel, *Anodonta cygnea* L. Acta Biol Hung. 1977; 28(3): 259-272.

50. Pentreath VW. Functions of invertebrate glia. In: Ali MA, editor. Nervous systems in invertebrates. New York: Plentum Press; 1987. p. 61-103.

51. Coles JA, Abbott JN. Signalling from neurones to glial cells in invertebrates.TINS. 1996; 19(8): 358-362.

52. Sonetti D, Ottaviani E, Bianchi F, Rodriguez M, Stefano M, Scharres B, et al. Microglia in invertebrate ganglia. Proc Natl Acad Sci U S A. 1994; 91(19):180-184.

53. Paemen LR, Porchet-Hennere E, Masson M, Leung MK, Hughes TK, Stefano GB. Glial localization of interleukin-1á in invertebrate ganglia. Cell Mol Neurobiol. 1992; 12(5): 463-472.

54. Miller SA, Harley JP. Zoology. 5th ed. Boston:The McGraw-Hill Companies; 2001

55. Owen G, McCrae JM. Further studies on the latero-frontal tracts of bivalves. Pro R Soc Lond [Biol]. 1976; 194: 527-544.

56. Pekkarinen M. Histology of the siphons of *Macoma balthica* (Bivalvia: Tellinidae). Ann Zool Fenn. 1986; 23:77-95.

57. Vitonis JEVV, Zaniratto CP, Machado FM, Passos FD. Comparative studies on the histology and ultrastructure of the siphons of two species of Tellinidae (Mollusca: Bivalvia) from Brazil.Zoologia. 2012; 29(3): 219-226.

58. Hardy D. Scallop Farming. Oxford: Fishing News Books; 1991.

59. Barber VC, Eileen EM, Land MF. The fine structure of the eye of the mollusc *Pecten maximus*.Z Zellforsch. 1967; 76: 295-312.

60. Cragg SM, Nott JA. The ultrastructure of the statocysts in the pediveliger larvae of *Pecten maximus* (L.) (Bivalvia). J Exp Mar Biol Ecol. 1977; 27(1): 23-36.

61. Frenkiel L, Moueza M. Ultrastructure des statocysts chez *Scrobicularia plana* et *Tellina tenuis* mollusques lamellibranches Tellinacea. J Mollus Stud. 1982. 482: 148-158.

62. Alexander CG. The osphradium of *Conus flavidus*.Mar Biol. 1970; 6:236-240.

63. Ferretti ME, Sonetti D, Pareschi MC, Buzzi M, Colamussi ML, Biondi C. Effect of serotonin and neuropeptides on adenylate cyclase of the central nervous system and peripheral organs of the freshwater snail *Planorbarius corneus*. Neurochem Int. 1996; 28(4): 417-424.

64. Tinikul Y, Mercier AJ, Sobhon P. Distribution of dopamine and octopamine in the central nervous system and ovary during the ovarian maturation cycle of the giant freshwater prawn, *Macrobrachium rosenbergii*.Tissue Cell. 2009; 41(6): 430-442.

65. Beiras R, Widdows J. Effect of the neurotransmitters dopamine, serotonin and norepinephrine on the ciliary activity of mussel (*Mytilus edulis*) larvae .Mar Biol. 1995; 122(4): 597-603.

66. Hartenstein V. Review: The neuroendocrine system of invertebrates: a developmental and evolutionary perspective. J Endocrinol. 2006; 190(3): 555-570.

67. Florkin M, Scheer BT. Chemical Zoology. London: Academic Press Inc.; 1972.

68. Tierney AJ, Kim T, Abrams R. Dopamine in crayfish and other crustaceans: Distribution in the central nervous system and physiological functions. Microsc Res Tech. 2003. 60(3): 325-335.

69. Fong PP, Noordhuis R, Ram JL. Dopamine reduces intensity of serotonin-induced spawning in the zebra mussel *Dreissena polymorpha* (Pallas). J Exp Zool. 1993; 266 (1): 79-83.

70. Khotimchenko YS, Deridovich II. The effect of dopamine and galoperidol on cyclic Amp in the gonad of the bivalve mollusc *Mizuhopecten yessoensis* and the sea urchin *Strongylocentrotus intermedius*. Comp Biochem Physiol C Comp Pharmacol. 1989; 92(1): 23-26.

71. Thorndyke MC, Goldsworthy GJ. Neurohormones in invertebrates. Cambridge: Cambridge University Press; 1988.

72. Saleuddin ASM, Wilbur KM. The Mollusca: Physiology Part 1. New York: Academic Press; 1983.

73. York PS, Cummins SF, Degnan SM, Woodcroft BJ, Degnan BM. Marked changes in neuropeptide expression accompany broadcast spawnings in the gastropods *Haliotis asinina*.Front Zool. 2012; 9(9): 1-16.

74. Joaquim S, Matias D, Lopes B, Arnold WS, Gaspar MB. The reproductive cycle of white clam *Spisula solida* (L.) (Mollusca: Bivalvia): Implications for aquaculture and wild stock management.Aquaculture. 2008; 281(1-4): 43-48.

75. Cardoso JFMF, Witte JIJ, van der Veer HW. Growth and reproduction of the bivalve *Spisula subtruncata* (da Costa) in Dutch coastal waters.J Sea Res. 2007; 57(4): 316-324.

76. Chesman BS, Langston WJ. Intersex in the clam *Scrobicularia plana*: a sign of endocrine disruption in estuaries? Biol Lett. 2006; 2(3): 420-422.

77. Gomes T, Gonzalez-Rey M, Bebianno MJ. Incidence of intersex in male clams *Scrobicularia*

plana in the Guadiana Estuary (Portugal).Ecotox. 2009; 18(8): 104-109.

78. Helm MM, Bourne N, Lovatelli A. Hatchery culture of bivalves. A practical manual. FAO Fisheries Technical Paper. No. 471. Rome: Food and Agriculture Organization of the United Nations (FAO); 2004.
79. Broom MJ. The biology and culture of marine bivalve molluscs of the genus *Anadara*. Manila: The international center for living aquatic resources management; 1985.
80. Ruiz Y, Suarez P, Alonso A, Longo E, Villaverde A, Juan FS. Environmental quality of mussel farms in the Vigo estuary: Pollution by PAHs, origin and effects on reproduction. Environ Pollut. 2011; 159(1): 250-265.
81. Bayne BL. Marine mussels: Their ecology and physiology. 1976, London: Cambridge University Press
82. Sola JC. Reproduction, population dynamics, growth and production of *Scrobicularia plana* da Costa (Pelecypoda) in the Bidasoa estuary, Spain.Aquat Ecol. 1997; 30(4): 283-296.
83. Pathansali D, Soon MK. Some Aspects of Cockle (*Anadara granosa* L.) Culture in Malaya. Proc Indo-Pacific Fish Coun. 1958; 8(2): 26-31.
84. Croll RP, Nason J, Van Minnen J. Characterization of central neurons in bivalves using antibodies raised against neuropeptides involved in the control of egg-laying in gastropods . Inv Reprod Dev. 1993; 24(3): 161-168.
85. Gagne´ F, Blaise C. Effects of municipal effluents on serotonin and dopamine levels in the freshwater mussel *Elliptio complanata*. Comp Biochem Physiol C. 2003; 136(2): 117–125.
86. Tsai PS. Gonadotropin-releasing hormone in invertebrates: Structure, function, and evolution. Gen Comp Endocrinol. 2006; 148(1): 48-53.
87. Khotimchenko YS, Deridovich II. The effect of dopamine and galoperidol on cyclic AMP in the gonad of the bivalve mollusc *Mizuhopecten yessoensis* and the sea urchin *Strongylocentrotus intermedius*. Comp Biochem Physiol C Comp Pharmacol. 1989; 92(1): 23-26.
88. Osada M, Normura T. Estrogen effect on the seasonal levels of catecholamines in the scallop *Patinopecten yessooensis*. Comp Biochem Physiol. 1989; 93(2): 349-353.
89. Ketata I, Denier X, Hamza-Chaffai A, Minier C. Endocrine-related reproductive effects in molluscs. Comp Biochem Physiol C Toxicol Pharmacol. 2008; 147(3): 261-270.
90. Jadhav ML, Lomte SV. Neurosecretory Activity of the freshwater Bivalve, *Lamellidens corriaus* (Prasad) (Mollusca: Lamellibranchiata). Proc Indian natn Sci Acad A. 1981; 47(4): 496-500.
91. Diamanti-Kandarakis E, Bourguignon JP, Giudice LC, Hauser R, Prins GS , Soto AM , et al. Review Endocrine-disrupting chemicals: An endocrine society scientific statement. Endocr Rev. 2009; 30(4): 293-342.
92. Overgaard A, Holst K, Mandrup KR, Boberg J, Christiansen S, Jacobsen PR, et al. The effect of perinatal exposure to ethinyloestradiol or a mixture of endocrine disrupting pesticides on kisspeptin neurons in the rat hypothalamus. NeuroToxicol. 2013; 37: 154-162.
93. Ceh K, Majdic G. Pesticides as Endocrine Disruptors.Slov Vet Res. 2010; 47(4): 163-166.
94. Cubero-Leon E, Ciocan CM, Hill EM, Osada M, Kishida M, Itoh N, et al. Estrogens disrupt serotonin receptor and cyclooxygenase mRNA expression in the gonads of mussels (*Mytilus edulis*). Aquat Toxicol. 2010; 98(2): 178-187.
95. Zhou J, Xiao-Shan Z, Zhong-Hua C. Endocrine disruptors: an overview and discussion on issues surrounding their impact on marine animals. J Mar Anim Ecol. 2009; 2(2): 7-17.
96. Hutchinson TH. Reproductive and developmental effects of endocrine disrupters in invertebrates: in vitro and in vivo approaches.Toxicol Lett. 2002; 131(1-2): 75-81.
97. Silva P, Rocha MJ, Cruzeiro C, Malhão F, Reis B, Urbatzka R, et al. Testing the effects of ethinylestradiol and of an environmentally relevant mixture of xenoestrogens as found in the Douro River (Portugal) on the maturation of fish gonads—A stereological study using the zebrafish (*Danio rerio*) as model.Aquat Toxicol. 2012; 15(124–125): 1-10.
98. Norris DO, Carr JA. Endocrine disruption: Biological basis for health effects in wildlife and humans. New York: Oxford University Press; 2006.
99. World Health Organization (WHO). The world health report 2002: Reducing risks, promoting healthy life. Geneva (Switzerland); 2002.
100. Ribeiro C, Pardal MA, Martinho F, Margalho R, Tiritan ME, Rocha E, et al. Distribution of endocrine disruptors in the Mondego river estuary, Portugal. Environ Monit Assess. 2009; 149(1-4): 183-193.

Revised Rates for 2014 (Institutional)

Title	Freequency	Rate (Rs): India	Rate ($):ROW
Dermatology International	2	2500	280
Gastroenterology International	2	3500	360
Indian Journal of Agriculture Business	2	4500	300
Indian Journal of Anatomy	2	3200	260
Indian Journal of Ancient Medicine and Yoga	4	6600	330
Indian Journal of Anesthesia and Analgesia	2	4000	600
Indian Journal of Anthropology	2	8000	500
Indian Journal of Applied Physics	2	3500	400
Indian Journal of Biology	2	1500	170
Indian Journal of Cancer Education and Research	2	4500	500
Indian Journal of Communicable Diseases	2	1000	58
Indian Journal of Dental Education	4	3200	288
Indian Journal of Forensic Medicine and Pathology	4	12500	576
Indian Journal of Forensic Odontology	4	3200	288
Indian Journal of Genetics and Molecular Research	2	5000	262
Indian Journal of Law and Human Behavior	2	5000	500
Indian Journal of Library and Information Science	3	7500	600
Indian Journal of Maternal-Fetal & Neonatal Medicine	2	4500	400
Indian Journal of Mathematics and Statistics	2	3000	200
Indian Journal of Medical & Health Sciences	2	1800	120
Indian Journal of Obstetrics and Gynecology	2	2000	200
Indian Journal of Pathology: Research and Practice	2	3000	915
Indian Journal of Plant and Soil	2	5000	1700
Indian Journal of Preventive Medicine	2	3200	270
Indian Journal of Reproductive Science and Medicine	4	3000	180
Indian Journal of Scientific Computing and Engineering	2	3300	280
Indian Journal of Surgical Nursing	3	1800	70
Indian Journal of Trauma & Emergency Pediatrics	4	6500	302
International Journal of Agricultural & Forest Meteorology	2	8000	800
International Journal of Food, Nutrition & Dietetics	2	3200	900
International Journal of History	2	6000	500
International Journal of Neurology and Neurosurgery	2	7500	276
International Journal of Political Science	2	5000	400
International Journal of Practical Nursing	3	1500	70
International Physiology	2	4000	240
Journal of Animal Feed Science and Technology	2	3500	280
Journal of Cardiovascular Medicine and Surgery	2	5500	238
Journal of Orthopaedic Education	2	2500	190
Journal of Pharmaceutical and Medicinal Chemistry	2	3000	350
Journal of Psychiatric Nursing	3	1800	70
Journal of Social Welfare and Management	4	6600	276
Meat Science International	2	5000	500
Microbiology and Related Research	2	3800	150
New Indian Journal of Surgery	4	6500	360
Ophthalmology and Allied Sciences	2	3000	150
Otolaryngology International	2	2000	300
Pediatric Education and Research	4	3200	150
Physiotherapy and Occupational Therapy Journal	4	7000	360
Urology, Nephrology and Andrology International	2	2200	350

Terms of Supply:

1. Advance payment required by Demand Draft payable to Red Flower Publicaion Pvt. Ltd. payable at Delhi.
2. Cancellation not allowed except for duplicate payment.
3. Agents allowed 10% discount.
4. Claim must be made within six months from issue date.

Order from

Red Flower Publication Pvt. Ltd., 48/41-42, DSIDC, Pocket-II, Mayur Vihar Phase-I, Delhi - 110 091 (India), Tel: 91-11-22754205, 45796900, Fax: 91-11-22754205. E-mail: redflowerppl@vsnl.net, redflowerppl@gmail.com, Website: www.rfppl.co.in

Red Flower Publication Pvt. Ltd.

Presents its Book Publications for sale

1. Breast Cancer: Biology, Prevention and Treatment	**Rs.395/$100**
2. Child Intelligence	**Rs.150/$50**
3. Pediatric Companion	**Rs.250/$50**

Order from

Red Flower Publication Pvt. Ltd.
48/41-42, DSIDC, Pocket-II, Mayur Vihar, Phase-I
Delhi - 110 091 (India)
Tel: 91-11-22754205, 45796900, Fax: 91-11-22754205
E-mail: redflowerppl@gmail.org, redflowerppl@vsnl.net
Website: www.rfppl.co.in

Guidelines for Authors

Manuscripts must be prepared in accordance with "Uniform requirements for Manuscripts submitted to Biomedical Journal" developed by international committee of medical Journal Editors.

Types of Manuscripts and Limits

Original articles: Up to 3000 words excluding references and abstract and up to 10 references.

Original articles: Up to 2500 words excluding references and abstract and up to 10 references.

Case reports: Up to 1000 words excluding references and abstract and up to 10 references.

Online Submission of the Manuscripts

Articles can also be submitted online from http://www.rfppl.com (currently send your articles through e-mail attachments)

I) First Page File: Prepare the title page, covering letter, acknowledgement, etc. using a word processor program. All information which can reveal your identity should be here. use text/rtf/doc/PDF files. Do not zip the files.

2) Article file: The main text of the article, beginning from Abstract till References (including tables) should be in this file. Do not include any information (such as acknowledgement, your name in page headers, etc.) in this file. Use text/rtf/doc/PDF files. Do not zip the files. Limit the file size to 400 kb. Do not incorporate images in the file. If file size is large, graphs can be submitted as images separately without incorporating them in the article file to reduce the size of the file.

3) Images: Submit good quality color images. Each image should be less than 100 kb in size. Size of the image can be reduced by decreasing the actual height and width of the images (keep up to 400 pixels or 3 inches). All image formats (jpeg, tiff, gif, bmp, png, eps etc.) are acceptable; jpeg is most suitable.

Legends: Legends for the figures/images should be included at the end of the article file.

If the manuscript is submitted online, the contributors' form and copyright transfer form has to be submitted in original with the signatures of all the contributors within two weeks from submission. Hard copies of the images (3 sets), for articles submitted online, should be sent to the journal office at the time of submission of a revised manuscript. Editorial office: **Red Flower Publication Pvt. Ltd., 48/41-42, DSIDC, Pocket-II, Mayur Vihar Phase-I, Delhi – 110 091, India, Phone: 91-11-22754205, 45796900, Fax: 91-11-22754205, E-mail: redflowerppl@vsnl.net.**

Preparation of the Manuscript

The text of observational and experimental articles should be divided into sections with the headings: Introduction, Methods, Results, Discussion, References, Tables, Figures, Figure legends, and Acknowledgment. Do not make subheadings in these sections.

Title Page

The title page should carry

- Type of manuscript (e.g. Original article, Review article, Case Report)
- The title of the article, which should be concise, but informative;
- Running title or short title not more than 50 characters;
- The name by which each contributor is known (Last name, First name and initials of middle name), with his or her highest academic degree(s) and institutional affiliation;
- The name of the department(s) and institution(s) to which the work should be attributed;
- The name, address, phone numbers, facsimile numbers and e-mail address of the contributor responsible for correspondence about the manuscript;
- The total number of pages, total number of photographs and word counts separately for abstract and for the text (excluding the references and abstract);
- Source(s) of support in the form of grants, equipment, drugs, or all of these;
- Acknowledgement, if any; and
- If the manuscript was presented as part at a meeting, the organization, place, and exact date on which it was read.

Abstract Page

The second page should carry the full title of the manuscript and an abstract (of no more than 150 words for case reports, brief reports and 250 words for original articles). The abstract should be structured and state the Context (Background), Aims, Settings and Design, Methods and Material, Statistical analysis used, Results and Conclusions. Below the abstract should provide 3 to 10 keywords.

Introduction

State the background of the study and purpose of thestudy and summarize the rationale for the study or observation.

Methods

The methods section should include only information that was available at the time the plan or protocol for the study was written such as study approach, design, type of sample, sample size, sampling technique, setting of the study, description of data collection tools and

methods; all information obtained during the conduct of the study belongs in the Results section.

Reports of randomized clinical trials should be based on the CONSORT Statement (http://www. consort-statement. org). When reporting experiments on human subjects, indicate whether the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000 (available at http://www.wma.net/e/policy/l 7-c_e.html).

Results

Present your results in logical sequence in the text, tables, and illustrations, giving the main or most important findings first. Do not repeat in the text all the data in the tables or illustrations; emphasize or summarize only important observations. Extra or supplementary materials and technical details can be placed in an appendix where it will be accessible but will not interrupt the flow of the text; alternatively, it can be published only in the electronic version of the journal.

Discussion

Include summary of key findings (primary outcome measures, secondary outcome measures, results as they relate to a prior hypothesis); Strengths and limitations of the study (study question, study design, data collection, analysis and interpretation); Interpretation and implications in the context of the totality of evidence (is there a systematic review to refer to, if not, could one be reasonably done here and now?, what this study adds to the available evidence, effects on patient care and health policy, possible mechanisms); Controversies raised by this study; and Future research directions (for this particular research collaboration, underlying mechanisms, clinical research). Do not repeat in detail data or other material given in the Introduction or the Results section.

References

List references in alphabetical order. Each listed reference should be cited in text (not in alphabetic order), and each text citation should be listed in the References section. Identify references in text, tables, and legends by Arabic numerals in square bracket (e.g. [10]). Please refer to ICMJE Guidelines (http://www.nlm.nih.gov/bsd/uniform_requirements.html) for more examples.

Standard journal article

[1] Flink H, Tegelberg Å, Thörn M, Lagerlöf F. Effect of oral iron supplementation on unstimulated salivary flow rate: A randomized, double-blind, placebo-controlled trial. J Oral Pathol Med 2006;35:540-7.

[2] Twetman S, Axelsson S, Dahlgren H, Holm AK, Källestål C, Lagerlöf F, et al. Caries-preventive effect of fluoride toothpaste: A systematic review. Acta Odontol Scand 2003;61:347-55.

Article in supplement or special issue

[3] Fleischer W, Reimer K. Povidone iodine antisepsis. State of the art. Dermatology 1997;195 Suppl 2:3-9.

Corporate (collective) author

[4] American Academy of Periodontology. Sonic and ultrasonic scalers in periodontics. J Periodontol 2000;71:1792-801.

Unpublished article

[5] Garoushi S, Lassila LV, Tezvergil A, Vallittu PK. Static and fatigue compression test for particulate filler composite resin with fiber-reinforced composite substructure. Dent Mater 2006.

Personal author(s)

[6] Hosmer D, Lemeshow S. Applied logistic regression, 2nd edn. New York: Wiley-Interscience; 2000.

Chapter in book

[7] Nauntofte B, Tenovuo J, Lagerlöf F. Secretion and composition of saliva. In: Fejerskov O, Kidd EAM, editors. Dental caries: The disease and its clinical management. Oxford: Blackwell Munksgaard; 2003. p. 7-27.

No author given

[8] World Health Organization. Oral health surveys - basic methods, 4th edn. Geneva: World Health Organization; 1997.

Reference from electronic media

[9] National Statistics Online—Trends in suicide by method in England and Wales, 1979-2001. www.statistics.gov.uk/downloads/theme_health/HSQ 20.pdf (accessed Jan 24, 2005): 7-18. Only verified references against the original documents should be cited. Authors are responsible for the accuracy and completeness of their references and for correct text citation. The number of reference should be kept limited to 20 in case of major communications and 10 for short communications.

More information about other reference types is available at www.nlm.nih.gov/bsd/uniform_requirements.html, but observes some minor deviations (no full stop after journal title, no issue or date after volume, etc).

Tables

Tables should be self-explanatory and should not duplicate textual material.

Tables with more than 10 columns and 25 rows are not acceptable.

Number tables, in Arabic numerals, consecutively in the order of their first citation in the text and supply a brief title for each.

Explain in footnotes all non-standard abbreviations that are used in each table.

For footnotes use the following symbols, in this sequence: *, ¶, †, ‡‡,

Illustrations (Figures)

Graphics files are welcome if supplied as Tiff, EPS, or PowerPoint files of minimum 1200x1600 pixel size. The minimum line weight for line art is 0.5 point for optimal printing.

When possible, please place symbol legends below the figure instead of to the side.

Original color figures can be printed in color at the editor's and publisher's discretion provided the author agrees to pay

Type or print out legends (maximum 40 words, excluding the credit line) for illustrations using double spacing, with Arabic numerals corresponding to the illustrations.

Sending a revised manuscript

While submitting a revised manuscript, contributors are requested to include, along with single copy of the final revised manuscript, a photocopy of the revised manuscript with the changes underlined in red and copy of the comments with the point to point clarification to each comment. The manuscript number should be written on each of these documents. If the manuscript is submitted online, the contributors' form and copyright transfer form has to be submitted in original with the signatures of all the contributors within two weeks of submission. Hard copies of images should be sent to the office of the journal. There is no need to send printed manuscript for articles submitted online.

Reprints

Journal provides no free printed reprints, however a author copy is sent to the main author and additional copies are available on payment (ask to the journal office).

Copyrights

The whole of the literary matter in the journal is copyright and cannot be reproduced without the written permission.

Declaration

A declaration should be submitted stating that the manuscript represents valid work and that neither this manuscript nor one with substantially similar content under the present authorship has been published or is being considered for publication elsewhere and the authorship of this article will not be contested by any one whose name (s) is/are not listed here, and that the order of authorship as placed in the manuscript is final and accepted by the co-authors. Declarations should be signed by all the authors in the order in which they are mentioned in the original manuscript. Matters appearing in the Journal are covered by copyright but no objection will be made to their reproduction provided permission is obtained from the Editor prior to publication and due acknowledgment of the source is made.

Abbreviations

Standard abbreviations should be used and be spelt out when first used in the text. Abbreviations should not be used in the title or abstract.

Checklist

- Manuscript Title
- Covering letter: Signed by all contributors
- Previous publication/ presentations mentioned Source of funding mentioned
- Conflicts of interest disclosed

Authors

- Middle name initials provided.
- Author for correspondence, with e-mail address provided.
- Number of contributors restricted as per the instructions
- Identity not revealed in paper except title page (e.g. name of the institute in Methods, citing previous study as 'our study')

Presentation and Format

- Double spacing
- Margins 2.5 cm from all four sides
- Title page contains all the desired information. Running title provided (not more than 50 characters)
- Abstract page contains the full title of the manuscript
- Abstract provided: Structured abstract provided for an original article.
- Key words provided (three or more)
- Introduction of 75-100 words
- Headings in title case (not ALL CAPITALS).

References cited in square brackets

- ☞ References according to the journal's instructions

Language and grammar

- ☞ Uniformly American English
- ☞ Abbreviations spelt out in full for the first time. Numerals from 1 to l0 spelt out
- ☞ Numerals at the beginning of the sentence spelt out

Tables and figures

- ☞ No repetition of data in tables and graphs and in text.
- ☞ Actual numbers from which graphs drawn, provided.
- ☞ Figures necessary and of good quality (color)
- ☞ Table and figure numbers in Arabic letters (not Roman).
- ☞ Labels pasted on back of the photographs (no names written)
- ☞ Figure legends provided (not more than 40 words)
- ☞ Patients' privacy maintained, (if not permission taken)
- ☞ Credit note for borrowed figures/tables provided
- ☞ Manuscript provided on a CDROM (with double spacing)

Submitting the Manuscript

- ☞ Is the journal editor's contact information current?
- ☞ Is a cover letter included with the manuscript? Does the letter

1. Include the author's postal address, e-mail address, telephone number, and fax number for future correspondence?
2. State that the manuscript is original, not previously published, and not under concurrent consideration elsewhere?
3. Inform the journal editor of the existence of any similar published manuscripts written by the author?
4. Mention any supplemental material you are submitting for the online version of your article?
5. Contributors' Form (to be modified as applicable and one signed copy attached with the manuscript)

Subject Index

Subject Index

Author Index

Author Index

Call for Reviewers

The Indian Journal of Anatomy (ISSN 2320–0022) is a tri-annual print and online journal of the **Red Flower Publication Pvt. Ltd.** publishes original and peer-reviewed articles, for the dissemination of anatomical knowledge with clinical, surgical and imaging guidance. Includes articles of history, reviews and biographies, locomotors, splachnology, neuroanatomy, imaging anatomy, anatomical variations, anatomical techniques, education and pedagogy in anatomy, Human Anatomy, Veterinary Anatomy, Embryology, Gross Anatomy (Macroscopic), Microscopic Anatomy (Histology, Cytology), Plant Anatomy (Phytotomy), Comparative Anatomy, editorials, letters to the editor, and case reports. Articles of veterinary anatomy, comparative and other morphological sciences are accepted.

Readership: Anatomical specialties, veterinarian, embryologists.

Indexing Information: Index Copernicus, Poland, Google Scholar, ProQuest, USA, Genamics JournalSeek.

One must have at least five years of experience in the field after completion of the education in that field and at least five original research papers in journal(s).

Please note that the acceptance of your application will be at the sole discretion of the editors.

Please provide your complete information and affiliation in brief through e-mail or you can register your self on our website www.rfppl.org.

For more information, please contact:

Publication–in-charge

Red Flower Publication Pvt. Ltd.

48/41-42, DSIDC, Pocket-II

Mayur Vihar Phase-I

Delhi – 110 091

India

Phone: 91-11-22754205, 45796900, Fax: 91-11-22754205

E-mail: redflowerppl@vsnl.net, redflowerppl@gmail.com

Website: www.rfppl.co.in

Indian Journal of Anatomy

Library Recommendation Form

If you would like to recommend this journal to your library, simply complete the form below and return it to us. Please type or print the information clearly. We will forward a sample copy to your library, along with this recommendation card.

Please send a sample copy to:

Name of Librarian

Library

Address of Library

Recommended by:

Your Name/ Title

Department

Address

Dear Librarian,

I would like to recommend that your library subscribe to the **Indian Journal of Anatomy**. I believe the major future uses of the journal for your library would be:

1. As useful information for members of my specialty.
2. As an excellent research aid.
3. As an invaluable student resource.
4. **I have a personal subscription and understand and appreciate the value an institutional subscription would mean to our staff.**
5. Other

Should the journal you're reading right now be a part of your University or institution's library? To have a free sample sent to your librarian, simply fill out and mail this today!

Stock Manager

Red Flower Publication Pvt. Ltd.

48/41-42, DSIDC, Pocket-II, Mayur Vihar, Phase-I

Delhi - 110 091 (India)

Tel: 91-11-22754205, 45796900, Fax: 91-11-22754205

E-mail: redflowerppl@gmail.com, redflowerppl@vsnl.net

Website: www.rfppl.co.in