Brief Communication

Percutaneous multiple K-wire fixation for humeral shaft fractures

Abdul Q. Khan, MS, Aftab A. Iraqi, MS, Mohammad-Khalid A. Sherwani, MS, Mazhar Abbas, MS, Adesh Sharma, MBBS.

Humeral shaft fractures are one of the common injuries, following Musculo-skeletal trauma. Being the most important bone of the upper extremity involved in the skilled movements, the appropriate management of the humeral shaft fractures is very important. There are various modalities of management for the humeral shaft fractures ranging from non-operative to operative. Non-operative management techniques include; hanging cast, U-slab, U-cast, shoulder spica, braces, and so on. Disadvantages of these non-operative methods are stiffness of the shoulder and elbow joints, non-union, delayed union due to distraction, and mal-union. Open reduction and internal fixation with narrow/broad dynamic compression plate (DCP) and screws has its own demerits, such as, extensive soft tissue dissection, significant blood loss, risk of intra operative radial nerve injury, impaired periosteal vascular supply to the fracture fragment, leading to delayed union/non-union, implant failure due to osteoporosis. Intramedullary stabilization of humeral shaft fractures avoids these disadvantages, but the nails are not without complications. Unlocked nails have fallen out of favor due to failure to provide good rotational stability and frequent slipping, thus, causing irritation to the joint. However, locked nails provide a good rotational stability, but a potential risk of radial nerve injury remains, due to the distal locking screws.

In the present study, Kirschner wires (K-wires) have been used to achieve closed intramedullary fixation. The K-wires are less expensive, universally available, and more flexible than the Hackethal nails, as they allow smoother introduction into the medullary cavity and provide a dynamic fixation without compromising stability. This prospective study was conducted at the Department of Orthopedic Surgery, Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University, Aligarh. The study included 86 cases of the diaphyseal humerus fractures, which were treated with closed intramedullary K-wire fixation. Patients of all age groups were included in this study, ranging from 8-65 years.

We included polytrauma patients, displaced fractures in adults, not amenable to closed reduction. In children, only those cases, in which closed reduction failed or the fractures re-displaced after initial successful reduction.

Preoperative management. Careful examination of the patient was performed to rule out any emergent systemic problem, and if present were taken care of. After ruling out the other serious medical complications, attention was paid to the upper extremity diaphyseal fractures.

Operative technique. Preparation of the Kirschner Wire. The K-wires of 50 cm length were chosen with the thickness according to the age of the patient and width of the intramedullary canal. Two to 4 K-wires of 2-3 mm thicknesses were inserted. The K-wires were bent to 30°-40° at a point of 1-1.5 cm from the tip, which helped in the progress of the wire across the fracture, as well as in reduction of the fracture. Tips of the wires were made blunt to avoid perforation of the cortex. The opposite end of the wire was bent at an angle of 90°, around 8-10 cm from the other end, opposite to the initial bend. This helped in easy maneuvering of wire and controlling the direction of the tip of the K-wire passing through the intramedullary canal.

Steps of surgery. The reduction of the fracture was checked under the image intensifier. For achieving reduction, manual traction, and fracture site manipulation was carried out. A window of 0.5 x 0.5 cm diameter was made in the posterior cortex, approximately 1.5-2.5 cm proximal to olecranon fossa, by using drill bit and later enlarging the hole with the help of bone awl. Bent-tip wires were introduced into the medullary canal of the bone, through the prepared hole under the image intensifier control. Wires were gradually advanced in the medullary canal by rotation or by hammering with pliers and mallet, until it reached the fracture site. At this point, reduction was carried out under the image control, and the wire negotiated into the second fragment. Wires were then engaged in the metaphyseal region of the second fragment (Figures 1a & 1b). The tips of wires were embedded in different directions, so as to give better stability and hold. Protruding distal end of the wires were cut, bent into “hairpin bend” and buried under the soft tissues and the skin.

Majorities of the patients were males (69.4%). Mean age of the patients was 31 years. The most common mode of injury was fall from height, accounting for nearly 45.8% of all cases. In our study, road traffic accident was the second most frequent cause (43%) of fractures. Among these, 4 patients had associated fracture shaft of femur and 3 patients had associated head injury. In this study, out of 86 fractures, majority (78.95%) were simple fractures, 14 fractures were of compound Grade I, only one case of each compound, Grade II and III, were included in this study. Most of the humeral shaft fractures were located in the region of the humeral shaft fractures are one of the common injuries, following Musculo-skeletal trauma. Being the most important bone of the upper extremity involved in the skilled movements, the appropriate management of the humeral shaft fractures is very important. There are various modalities of management for the humeral shaft fractures ranging from non-operative to operative. Non-operative management techniques include; hanging cast, U-slab, U-cast, shoulder spica, braces, and so on. Disadvantages of these non-operative methods are stiffness of the shoulder and elbow joints, non-union, delayed union due to distraction, and mal-union. Open reduction and internal fixation with narrow/broad dynamic compression plate (DCP) and screws has its own demerits, such as, extensive soft tissue dissection, significant blood loss, risk of intra operative radial nerve injury, impaired periosteal vascular supply to the fracture fragment, leading to delayed union/non-union, implant failure due to osteoporosis. Intramedullary stabilization of humeral shaft fractures avoids these disadvantages, but the nails are not without complications. Unlocked nails have fallen out of favor due to failure to provide good rotational stability and frequent slipping, thus, causing irritation to the joint. However, locked nails provide a good rotational stability, but a potential risk of radial nerve injury remains, due to the distal locking screws.

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tenderness and lack of abnormal mobility at fracture site in any plane. In our study, most of the humeral shaft fractures (93%) united between 8-12 weeks, time after the operation. In our study, the average time to union was 10 weeks. There were 5 fractures, which had delayed union. Two fractures went into non-union. None of the fracture took more than 24 weeks to unite.

All the cases were given some type of support postoperatively; this immobilization was continued until the early signs of union were identified on the x-rays in follow-ups. When good quality of bridging callus was visible on x-rays, these supports were discarded and patient was advised to initiate physiotherapy of involved joints. In this study, we had performed closed reduction under image intensifier and internal fixation with intramedullary K-wires. Recently, there has been growing trend towards the flexible intramedullary nailing for pediatric diaphyseal long bone fractures. However, this study included all the age groups, so as to evaluate the effectiveness of this method, even in adults. Union rates in our study were 93%. Majority of fractures united in less than 16 weeks. Five cases took longer period to unite and went into delayed union. Two fractures had gone into non-union. These fractures were later re-operated and open reduction, and internal fixation with Narrow DCP and cancellous bone grafting was performed. The average time to union of humeral shaft fractures was 10 weeks in our study. Union rates of humeral shaft fractures in our series are comparable to other studies. Qidwai\textsuperscript{1} has reported the union rates of 93% using K-wires in humerus. Shazor et al\textsuperscript{2} reported approximately 91.5% union rates using retrograde Ender nailing. Other studies using humeral interlocking nails for fixation, such as Stannard et al\textsuperscript{3}, have also reported similar union rates in their series. Skin irritation and pain by the protruding distal ends of wires at the portal of entry was the most common complication (15.79%). This complication was encountered in other studies also.\textsuperscript{1,4,5} This problem of irritation by protruding wire tips was overcome by bending the tips of the wire in a U-shape or hairpin bend, and embedding the end of wire deep under the skin with the help of K-wire punch. These minimizes the irritation by the protruding wire tips.

Flexible intramedullary nailing of humerus is an easy, safe, and effective method. Flexible intramedullary nails (Ender or Hackethal nails) have given satisfactory results, however, K-wires are more flexible, less expensive, and universally available, and provide a dynamic fixation without compromising stability. Closed intramedullary K-wiring is a dynamic biological method of fixation with less damage to the muscles or the periosteum, leaving fracture hematoma intact, thus, leading to early bridging callus formation.

Figure 1 • Radiographic image a) on the day of trauma (fracture shaft of humerus at the junction of proximal approximately one-third and distal of two-thirds) b) on the 16 weeks after the operation (fracture was united with k-wires in situ).
There is no interference with endosteal or periosteal blood supply. Micro movements at the fracture site stimulate early bridging callus by converting shearing into compression forces. In this technique, cosmetic damage is minimal, with minimal scarring at the entry points of the K-wires. This technique is cost-effective, as there is reduced hospital stay as compared to other methods; also implant is very cheap and easily available. Intramedullary K-wires provide a combination of elastic mobility and stability. In contrast with the techniques involving rigid fixation, stability is not only ensured by intramedullary K-wires, but also by the bone and the surrounding soft tissues. The K-wires provide internal elastic support, channeling forces, and preventing excessive displacement by automatic adjustment of bone fragments. The muscles acting as guy-ropes, help in spontaneous postoperative correction of slight angular deviation and retention of normal curvature of long bones. Living tissue provides stability and aids in rapid healing, and there is minimal disturbance of bone growth, thus, leading to rapid return of function. Hence, it is a physiological method of treatment. Axial stability is provided by 3-point fixation of bones by the K-wires, and rotational stability is achieved by angled wire tips, anchoring at different points inside the metaphyseal end of bones. Percutaneous closed K-wire fixation of diaphyseal fractures of the humerus is a safe, reliable, and effective method of fixation, and is recommended for all fresh fractures where internal fixation is indicated.

References


Negative suction versus non-negative suction after coronary surgery

Basel Harahsheh, MD, FRCS.

There is a controversy whether the institution of negative suction for cases of coronary artery bypass surgery (CABG) affect the rate of Mediastinal bleeding. It has largely been based on non-scientific principles whether to use negative suction of 20 cm of water or not. This paper helps to answer this question. The Pubmed and Medline searches revealed no study that addresses this question. Consecutive cases of CABG were studied accordingly, whether negative suction was applied (Group A) or not (Group B) from October 2003 until May 2004; and chest tube drainage over the first 24 hours postoperative, the mortality rates, re-opening for bleeding, and postoperative pericardial effusions were analyzed. Table 1 showed the cases performed in each group. Approximately 281 consecutive cases of CABG alone or in combination with other procedures were studied. Negative suction was applied in 78 cases (28%). The male to female ratio was 3.2:1. Pure CABG was carried out in 258 cases (92%). Concomitant procedures included Mitral valve repair and replacement and aortic valve replacement. Redo surgery was performed in 16 cases (5.6%). Left internal thoracic artery was utilized in 81%. Average blood loss in group A was 870 ± 270 ml, and group B was 630 ± 215 ml giving a p<0.05. Overall, the re-opening rate was 19 cases, re-opening for bleeding occurred in 10 cases in group A, and 9 cases in group B (Table 1). Overall, there were 11 deaths (Table 1). Pure CABG had 7 deaths from a total of 258 cases, giving first time coronary mortality rate of 2.7%. A periocardial effusion occurred in 2 cases in group A, and 9 in group B (Table 1). Drainage of the pleura and mediastinum after cardiac surgery is usually achieved with plastic drains. Due to the nature of coronary artery bypass surgery, there is a great potential for bleeding postoperatively. Negative suction applied to the chest drains to facilitate their drainage capacity and prevent the drains from clotting off. Clotting off from the drains can lead to hemodynamic instability, cardiac tamponade, closure of grafts, and development of pericardial effusions. There was no paper on Pubmed or Medline searches, that specifically looked at the effect of negative suction on drainage post coronary artery surgery or the effect on residual pericardial and pleural effusions. Our study demonstrated an increase in total drainage with the use of negative suction; however, there were no effects...
on rates of re-opening for bleeding, development of pericardial effusion, and an overall mortality. It can be seen from our data, that the rates of residual effusions were higher in the control group; however, did not reach statistical significance. Although, there were more re-opening in the negative suction group, this also did not reach statistical significance. Despite the limitation of not being a randomized study, nonetheless, it shows that negative suction applied to the chest drains after CABG increase Mediastinal drainage, however, had no effect on re-opening rates and overall mortality.

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From the Department of Cardiac Surgery, Queen Alia Heart Institute, Amman, Jordan. Address correspondence and reprint requests to: Dr. Basel Harahsheh, Department of Cardiac Surgery, Queen Alia Heart Institute, Amman, Jordan. Tel. +795773838. Fax. +962 (6) 5715944 E-mail: basel_md@hotmail.com

Amyloid-depositing plasmacytoma of cervical spine masquerades as a granulomatous inflammatory reaction

Ibrahim S. Tillawi, MBBCh.

A case of plasmacytoma involving the lower cervical vertebral body is presented, in which the tumor resulted in lytic bone changes in the fourth cervical vertebral body with outward extension leading to the development of a large paravertebral soft tissue mass. Aspiration of the soft tissue component of the mass, showed a number of eosinophilic amorphous variable-sized clumps, inflammatory cells including large numbers of plasma cells, spindled shaped cells, multinucleated giant cells and blood, all suggesting that the lesion is benign in nature. Three pathologists, who independently had the lesion aspirated and cytopathologically examined, gave discrepant diagnosis, ranging from inflammatory granulomatous reaction to a highly lethal small cell variant of osteogenic sarcoma, not very much different in that from the differential diagnostic list given by the radiologist. This led the neurosurgeon to request frozen section assistance towards a definitive therapeutic surgical intervention; frozen section revealed the true nature of the lesion, which consisted of a plasmacytoma associated with secondary granulomatous reaction due to amyloid produced by the tumor cells. This communication emphasizes the need for the pathologists to be aware, not only of the characteristic appearance of amyloid on cytological preparations, but of its inherent capability of producing a granulomatous reaction; if its presence is overlooked, or not considered in the appropriate context, the pathologic diagnosis will change.

Table 1 - The cases performed in each group.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Group A (negative suction)</th>
<th>Group B</th>
<th>P-value</th>
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<tbody>
<tr>
<td>CABG</td>
<td>69</td>
<td>189</td>
<td></td>
</tr>
<tr>
<td>CABG + MV Repair</td>
<td>8</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>CABG + MVR</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CABG + AVR</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total (%)</td>
<td>78 (28)</td>
<td>203 (72)</td>
<td></td>
</tr>
<tr>
<td>Blood loss (ml) mean ± SD</td>
<td>870 ± 270</td>
<td>630 ± 215</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Re-opening (%)</td>
<td>10 (12.8)</td>
<td>9 (4.4)</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Pericardial effusion (%)</td>
<td>2 (2.5)</td>
<td>9 (4.4)</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>4 (5.1)</td>
<td>7 (3.4)</td>
<td>p&lt;0.05</td>
</tr>
</tbody>
</table>


References

A 43-year-old previously healthy male presented with a right sided brachialgia, progressive in nature, of few months duration. Clinical examination revealed the presence of the right sided weakness of ipsilateral elbow extension, without concomitant signs of myelopathy and flexor plantar responses. Neck movement was also markedly restricted. Computed tomography scan, revealed the presence of a heterogeneous irregular expansile and infiltrative large boney mass that destroyed the pedicle of the fourth cervical vertebral body and extended into the surrounding adjacent soft tissues, which was interpreted that it can similarly be inflammatory or neoplastic in nature. The mass was a fine needle aspirated by 3 pathologists who independently gave 3 different opinions after examining 3 different samples each obtained individually from a separate site from the large soft tissue mass. The aspirations generally showed variable degrees of admixtures of irregularly shaped eosinophilic amorphous clumps, inflammatory cells including large numbers of plasma cells, many “spindled” shaped cells, multinucleated giant cells, and blood. One pathologist opinion was that of a benign reactionary granulomatous process. The second pathologist thought that it might represent a small cell variant of osteogenic sarcoma of bone; amyloid fragments seen were thought to represent fragments of necrotic bone and “malignant osteoid”. The third pathologist considered the lesion to represent an aneurysmal bone cyst, based on the presence of blood, giant cells, and a scattering of “inflammatory cells included among which are plasma cells”. Subsequently, exploration was carried out, and excision of the most peripheral skeletal muscles, in addition to almost the entirety of the infiltrative mass along with a major portion of the centrally placed and almost totally collapsed, the fourth cervical vertebral body. Frozen section interpreted by an independent fourth pathologist, found that the lesion is a plasma cell neoplasm with amyloid production (amyloid tumor) with secondary granulomatous reaction. CD138 as well as kappa were evident in the same cells, which were simultaneously negative for lambda. On admission, complete blood count, erythrocyte sedimentation rates, serum calcium, phosphorus, beta 2-microglobulins, protein electrophoresis, and urine electrophoresis were all within the normal range. The initial bone marrow biopsy and aspiration revealed the presence of less than 5% plasma cells, and interpreted as a cellular marrow. The patient subsequently received radiotherapy to the region of the fourth cervical vertebral body spine and 4 cycles of chemotherapy (myleran and prednisolone).

Radiology is pathology-see-through; the list of diagnostic considerations will greatly aid the pathologist when it comes to finalize the pathological report. In the differential diagnosis of a fine-needle aspiration biopsy of soft tissue masses resulting from primary bone lytic lesions, a wide range of diagnostic considerations should be included depending on the predominating constituent cells in the aspirated material. Usually, some technical variables interfere in the final cytologic al diagnosis; one such factor includes the uniformity of the cytological spread, which truly depends on the cellular composition of the pass used, and this invariably influences the diagnostic accuracy in any case. Overlap conditions are of paramount importance to be segregated and identified; that by itself, primarily depends on several factors. Lesions that do include a heterogeneous and unequal admixture of giant cells, spindled cells, stromal vascularized fibroconnective tissue cells, and few other unrelated inflammatory cells with an inconspicuous amount of amyloid, will end up being diagnosed as either inflammatory or aneurysmal bone cyst on fine needle aspiration biopsy (FNAB) in this clinicopathologic setting, as was the case in this patient. Additionally, accurate identification of the true nature of amyloid on cytologic preparations and recognizing their presence is equally challenging. Although, previous reports and major textbooks have detailed their cytologic

revealed heterogeneously represented sheets and nests of plasma cells of variable maturational stages and sizes, between large masses of congophilic amyloid, and scattered large number of multinucleated giant cells, some of which containing very tiny amyloid material within their cytoplasm. In many occasions, the scalloped edges of the islands of amyloid were rimmed by spindled shaped cells, which characteristically had a cartwheel nucleus of plasma cells, and as shown later stained with CD138. Necrosis was not seen anywhere in the tumor. In the soft tissue component, one also observes irregular skeletal muscle fibers separated by dense plasma cell infiltrates and Congo red-positive amyloid. The diagnosis made an extramedullary plasmacytoma with amyloid production (amyloid tumor) with secondary granulomatous reaction.
Amyloid-depositing plasmacytoma

features, partly, the rare incidence of such tumors makes it a potentially difficult diagnosis and a diagnostic pitfall.\textsuperscript{1,2} Conversely, the straightforward diagnosis of extramedullary plasmacytoma with or without associated amyloid deposition, requires primarily the presence of a rather uniform preparation of invariably large number of discohesive plasma cells of stages of maturation and sizes, with an associated background of lymphoglandular bodies as well as occasional lymphocytes, and as minimal as possible stromal cells.\textsuperscript{3} It is such, that without these constituent cells, one cannot make the diagnosis of extramedullary plasmacytoma. Other factors that also interfere in the diagnosis of plasmacytoma includes; 1. The degree of differentiation of plasma cells 2. Relative frequency and proportion of distribution of the accompanying inflammatory/reactionary and stromal cells 3. Demonstrating unequivocal monoclonality in the examined cells.\textsuperscript{3} On the other end of the “neoplastic spectrum”, one should also consider other neoplasms, whose constituent discohesive neoplastic cells greatly mimic plasma cells in various other neoplasms, when the later assumes other shapes or grades of differentiation that may mimic plasma cells. Anaplastic melanoma, or aggressive non-Hodgkin’s lymphoma is such examples, and it depends on how the cytopathologist can easily make the distinction between these cell types sometimes; that will most likely require immunohistochemical staining.\textsuperscript{5} In one of the largest studies on FNAB of extramedullary plasma cell tumors, there was no emphasis made on the role of the giant cell as a cellular component of these neoplasms, especially with special reference to its close association and relationship to the amyloid deposition. Simultarily, intracytoplasmic amyloid observed within the cytoplasm of the giant cells did not receive any emphasis.\textsuperscript{5} The presence of a certain proportion of a giant cells in lytic bone lesions will primarily aid in the separation of a main giant cell tumor of bone from “reactionary” presence of giant cells in primary bone lesions; the combination of clinical, radiological, and the complete cellular composition alongside with giant cells help in the final distinction. With reference to the small cell variant of osteogenic sarcoma, especially if the needle passes into a zone of minimal osteoid formation, or other sarcoma composed mainly of small cells, can still pose a problem in the differential diagnosis. Amyloid can sometimes be confused (especially in scanty amounts and if the cyologic setting is right), with osteoid.\textsuperscript{4,5}

References


Maternal and fetal thyroid stimulating hormones and the fetal indices of maturation, growth, and development

\textbf{Oluwole O. Adeleoji, D.PHIL, George K. Oyakhire, FRCOG.}

\textbf{T}he thyroid stimulating hormone (TSH) occupies a central position in the hypothalamic-pituitary-thyroid axis, which regulates and controls the secretion of thyroid hormones.\textsuperscript{1} The developing fetus depends on the thyroid hormones for neurological maturation, growth, and development.\textsuperscript{2,3} Thyroid hormones are supplied by the mothers to the fetus through transplacental transfer until mid-gestation when the fetus begins to produce the hormones.\textsuperscript{3} The placenta is permeable to thyrotropin releasing hormone, tetra-iodothyronine (T\textsubscript{4}), and tri-iodothyronine (T\textsubscript{3}), however, TSH does not cross the placenta. In fact, the fetal hypothalamic-pituitary-thyroid axis develops relatively independent of maternal influence,\textsuperscript{4} and TSH production is determined by the thyroid hormone status. The maturation of negative feedback of thyroid hormone synthesis occurs by approximately mid-gestation, and elevated TSH concentrations were observed in infants as early as 2 weeks.\textsuperscript{3} An abnormal TSH is usually the first indication of thyroid dysfunction. Hence, TSH screening for thyroid diseases has been recommended.\textsuperscript{1,3} There is a growing interest in relative influence of maternal and fetal TSH on the growing fetus. Therefore, the objective of this study was to determine the correlation between maternal and fetal

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thyroid stimulating hormones and the fetal indices of maturation, growth, and development.

The subjects were 101 consecutive female patients (mean age 26.78 ± 6.25) with no known thyroid abnormalities who gave birth at the King Abdullah Hospital, Bisha, Saudi Arabia and their corresponding neonates. The preterm neonates were babies delivered after 20 weeks and before 37 weeks of completed gestation. After obtaining consent from the mothers, blood samples were collected from the mothers and the umbilical cords immediately after delivery into plain tubes for TSH and heparinized tubes for biochemical analytes. The TSH levels of maternal and cord blood were determined, since humans have homochondrial placentas consisting exclusively of fetal tissue. Moreover, the fetal physiological indices, which included gestational age, weight, and Apgar scores at one and 5 minutes, as well as the biochemical indices such as, glucose, calcium, total protein, albumin, and albumin/globulin (A/G) ratio were measured. These indices reflect fetal maturation, growth, and development. The TSH was measured using DELFIA (Perkin Elmer Inc., Finland) hTSH ultra assay, a solid phase 2 site fluoroimmunometric assay, based on direct sandwich technique, in which 3 monoclonal antibodies are directed against separate antigenic determinants on the human thyroid-stimulating hormone (hTSH) molecule. Biochemical analyses were carried out on Hitachi 912 chemistry autoanalyzer using Roche reagents.

The Statistical Package for Social Sciences Version 10.0 was used for the analysis of data. Student’s $t$-test and Pearson’s correlation coefficients were determined. The $p$ value of <0.05 was considered as a significant difference, while $R=1.0$ represented absolute positive correlation between the parameters. Table 1 shows that the maternal TSH level (4.01 ± 0.36 mU/L) was significantly lower than the fetal TSH level (8.16 ± 0.51 mU/L) ($p<0.05$). These values were within the normal ranges for the mothers and fetuses at the time of delivery. There was no significant difference between the mean TSH levels of preterm and term neonates ($p>0.05$). In addition, the results showed that the mean fetal glucose and total protein concentrations were significantly lower than the levels for their mothers ($p<0.05$), while the mean fetal calcium level and A/G ratio were significantly higher than the values for their mothers ($p<0.05$). The mean fetal albumin concentration was higher than that of their mothers, although, the difference was not significant ($p>0.05$). The results showed some degrees of correlation, albeit low, between maternal and fetal TSH levels ($R=0.08$), fetal TSH and gestational age ($R=0.08$), fetal TSH and weight ($R=0.20$), maternal TSH and Apgar score at one minute ($R=0.10$), and fetal TSH and Apgar score at 5 minutes ($R=0.20$). There was no appreciable correlation between maternal TSH and neonatal weight ($R=0.04$), maternal TSH and Apgar scores at 5 minutes ($R=0.01$), and fetal TSH and Apgar scores at one minute ($R=0.03$). Finally, both maternal and fetal TSH levels were appreciably correlated to the mean fetal glucose, calcium, total protein, albumin, and A/G ratio.

### Table 1 - Correlations between maternal and fetal thyroid stimulating hormone levels and the fetal indices.

<table>
<thead>
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<th>Parameters</th>
<th>Maternal (Mean ± SEM)</th>
<th>Fetal (Mean ± SEM)</th>
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<tr>
<td><strong>Maternal parameters (n=101)</strong></td>
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<tr>
<td>TSH* (n=101) (mU/L)</td>
<td>4.01 ± 0.36</td>
<td>8.16 ± 0.51</td>
<td>0.000</td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>5.05 ± 0.23</td>
<td>3.51 ± 0.26</td>
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<tr>
<td>Albumin (g/dl)</td>
<td>30.4 ± 0.68</td>
<td>33.40 ± 0.42</td>
<td>0.521</td>
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<tr>
<td>Total protein (g/dl)</td>
<td>59.10 ± 1.26</td>
<td>52.62 ± 1.10</td>
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<tr>
<td>Calcium mmol/L</td>
<td>2.26 ± 0.02</td>
<td>2.70 ± 0.02</td>
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<td>Albumin/glucose ratio</td>
<td>1.08 ± 0.02</td>
<td>1.78 ± 0.04</td>
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<tr>
<td><strong>Fetal parameters (n=101)</strong></td>
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<tr>
<td>TSH</td>
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<td>Apgar Score</td>
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<td>Calcium</td>
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<td>Albumin/glucose ratio</td>
<td>0.78</td>
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</table>

*Preterm (25) (<30 weeks), thyroid stimulating hormones (6.38 ± 0.90), term (75), TSH - thyroid stimulating hormones (6.39 ± 0.79) ($p=0.996$)

The fetal TSH could be assumed to be produced solely by the fetal pituitary gland since maternal TSH does not cross placenta. The higher fetal TSH level could be explained either on the basis of enhanced TSH release or impaired TSH degradation, which might be due to immaturity of the hepatic glycoprotein metabolic clearance system. Another reason might be the increase in fetal TSH late in the third trimester, which continues up to 24 hours postnatal period. Nevertheless, it is conceivable that there is some degree of maternal influence on the fetal TSH production due to transplacental passage of T₄ and T₃. Hence, there was some degree of correlation between the maternal and fetal TSH levels. Thus, the fetus is not completely independent of maternal thyroid status in utero. The transplacental passage of T₄ has provided partial explanation for normal clinical appearance at birth of over 90% of infants with congenital hypothyroidism. Also, it explains the prevention of the development of mental retardation by early treatment of affected neonates with adequate thyroxine. The reasons for the absence of significant difference between preterm and term TSH levels could be explained by the matured gestational age of the preterm neonates in this study, with mean age of 35 weeks, and the probable error in the calculation of gestational age, which was based on maternal recollection that could be incorrect. Nevertheless, it has been reported that, although the preterms experience a transient hypothyroxinemia with a fall in serum FT₄, there is no TSH elevation. This is associated with lack of maturity of the hypothalamic-pituitary-thyroid axis resulting without a TSH surge in response to the hypothyroxinemia. This could create difficulty in detecting hypothyroidism, if TSH is used for screening premature neonates. The fetal thyroid status has been postulated to play a role in the weight of neonates and infants. It has been shown in utero studies that, fetuses with severe intrauterine growth restriction (IUGR) had significantly lower levels of FT₄, FT₃, and slight elevation of TSH. Intrauterine growth restriction is associated with placental insufficiency. Low levels of thyroid hormones, may contribute to reduced oxygen consumption by peripheral tissue to maintain viability at the expense of disrupting neurological development. The maternal TSH level showed appreciable positive correlations with Apgar scores at one minute, while the fetal TSH showed some correlation at 5 minutes. Both maternal and fetal thyroid status may be important in the fetal brain development. It has been suggested that some degree of compensation may occur if one or the other is lacking, but the differences in the neuropsychological development are still demonstrable in either case compared with euthyroidism. Maternal hypothyroidism has been associated with poorer neuropsychological expression in off-springs. Thus, it was reported that in the Netherlands, mothers with low FT₄ levels at 12 weeks gestation gave birth to babies who at 19 months of age had scores below tenth percentile of psychomotor index. Fetal glucose, which was used for growth and energy metabolism, is supplied partly from the mother, and partly by gluconeogenesis in the fetus. The lower fetal glucose level might be because the fetuses require less glucose for energy metabolism than their mothers. However, there were positive correlations between maternal and fetal TSH levels and the fetal glucose concentration. The higher value of the correlation coefficient between the maternal TSH and the fetal glucose could be a reflection of a greater maternal contribution to fetal glucose level. Thus, raised TSH level is associated with increased gluconeogenesis and glucose utilization, whereas, hypoglycemia and heat intolerance are associated with neonatal hypothyroidism. The fetus derives its calcium supply from the mother. The fetal calcium level was 16% higher, which agrees with previous reports of 10-20% higher fetal calcium concentrations than corresponding maternal levels. This could be due to the high turn over of calcium from bone development and modeling in the growing fetus. Also, the maternal and fetal TSH showed positive correlation with fetal calcium level, which reflects the important role of TSH in bone maturation and growth, and its involvement with calcium metabolism. The fetus derives its total protein partly from the mother and partly by fetal protein synthesis. Total protein level is associated with the body mass per surface area, which is less in fetuses than their mothers. Hence, the fetal total protein level was less than the mean level for the mothers. There were positive correlations between maternal and fetal TSH and fetal total protein, which are indicative of the role of TSH in the fetal development, maturation, and growth. The lower albumin concentrations of the mothers could result from hemodilution due to fluid retention during pregnancy. Nevertheless, there were positive correlations between maternal and fetal TSH and the fetal albumin level, which is compatible to the relationships with total protein. Furthermore, similar associations were also found between the maternal and fetal TSH and A/G ratios. The fetal A/G ratio was higher than that of the mothers due to the higher fetal albumin concentration.

In conclusion, this study showed that the maternal and fetal thyroid stimulating hormones played significant influential roles, and complement each other during the growth, maturation, and development of the fetus. Hence, there were positive correlations...
between the maternal and fetal TSH levels and the fetal physiological and biochemical indices.

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From the Department of Pathology, King Abdullah Hospital, Bisha, Kingdom of Saudi Arabia. Address correspondence and reprint requests to: Dr. Oluwole O. Adeleji, Department of Pathology, King Abdullah Hospital, PO Box 60, Bisha, Kingdom of Saudi Arabia. Tel. +966 (7) 6223333 Ext. 1149. E-mail: adeleji12us@yahoo.com

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