COMPARING THE TOXIC EFFECTS OF NONSTEROIDAL ANTI-INFLAMMATORY DRUGS (CELECOXIB AND IBUPROFEN) ON HEART, LIVER, AND KIDNEY IN RATS

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Received: 26 February 2018, Revised and Accepted: 18 April 2018

ABSTRACT

Objective: Nonsteroidal anti-inflammatory drugs (NSAIDs) do not reverse the disease progression, but they provide relief from pain and inflammation by inhibiting cyclooxygenase (COX) enzymes mediating the inflammatory pathway. Our aim was to make a meaningful comparison of both selective and non-selective COX-2 inhibitor to evaluate their toxic effects by measuring biochemical and histological alterations of heart, liver, and kidney.

Methods: This study was conducted on 18 Sprague-Dawley rats of both sexes for 30 days, rats were divided into three groups (control group, ibuprofen group, and celecoxib group) each group included six rats.

Results: The results are revealed that serum level of alanine aminotransferase, aspartate aminotransferase, alkaline phosphates, and total serum bilirubin was significantly increased (p<0.05) in ibuprofen and celecoxib group when compared with control, the highest level in celecoxib group, also serum level of urea was significantly elevated (p<0.05) in ibuprofen group when compared with control and celecoxib groups. Histopathological changes in cardiac tissue represented by vascular congestion and pericardial infiltration which are more prominent in celecoxib group, the changes in liver tissue revealed by vascular congestion and mild portal tract inflammation which is chronic in celecoxib group, while histological alterations in kidney tissue represented by severe vascular congestion with tubular necrosis which is more prominent in ibuprofen group.

Conclusion: Both ibuprofen and celecoxib group have toxic effects on heart, liver, and kidney represented by the biochemical and histopathological findings.

Keywords: Celecoxib, Ibuprofen, Toxicity, Biochemical markers, Histopathology, Heart, Liver, Kidney.

INTRODUCTION

Nonsteroidal anti-inflammatory drugs (NSAIDs) are the most widely used drugs in management of pain, fever, redness, and edema arising as a consequence of inflammatory mediators release [1,2]. NSAIDs exert their anti-inflammatory, analgesic, and antipyretic effects by inhibiting of prostaglandins (PGs) synthesis, by suppressing the enzyme cyclooxygenase (COX), which are the enzymes that convert arachidonic acid into PGs, thromboxanes, and prostacyclins [2,3]. Two isoforms of COX have been recognized: Cox-1 and COX-2. The "COX-1" isoenzyme is usually presented in all tissues [4,5] and its stimulation leads to the formation of "PGs" essential in the maintenance of organ systems such as protecting the stomach wall and the kidney functions [6]. On the other hand, "COX-2" is always unexpressed in most tissues under normal physiological conditions [7,8], but it is expressed when there is damaging in the body, leading to the induction of PGs synthesis [9].

Ibuprofen and celecoxib groups are "NSAIDs" mainly used for its antipyretic, anti-inflammatory, and analgesic properties [10]. The major mechanism of action of ibuprofen is the non-selective, reversible inhibition of the "COX enzymes COX-1 and COX-2" [11]. Ibuprofen is completely metabolized; the major route of elimination is oxidative metabolism by cytochrome p2C9 enzymes into inactive metabolites. Urinary excretion of the two major metabolites, "carboxy-ibuprofen" and "2-hydroxy-ibuprofen" represents 25% of the administered dose [12]. Celecoxib has also experimented in cancer prevention and has been used as an adjunct to surgery to limit the number of "adenomatous colorectal polyps" in patients with the genetic susceptibility for colon cancer syndrome, familial adenomatous polyposis [13,14]. Celecoxib is one of the subclasses of "NSAIDs" which were synthesized as "COX-2" selective inhibitors that are sometimes called coxibs [15,16]. Celecoxib expresses its anti-inflammatory and analgesic properties by blocking the synthesis of different inflammatory "prostanoids" [17]. However, the selectivity for COX-2 determined by in vitro is lower for celecoxib in comparison with other drugs in the coxib group (e.g., rofecoxib, valdecoxib, lumiracoxib, and etoricoxicib), it is very similar at therapeutic concentration in vivo. Celecoxib also has the ability to suppress COX-1 compared with other coxibs; however, the result of this with regard to its therapeutic efficacy and toxicity are not well understood [18,19]. Celecoxib is mainly metabolized in the liver, with very little drug <3% being excreted unchanged. The major routes of elimination for celecoxib are urine and feces. NSAIDs are in association with the incidence of serious adverse "cardiovascular thrombotic events" such as myocardial infarction and stroke. Risk may be associated with duration of use or pre-existing cardiovascular risk factors or diseases [20]. The objective of the study was to make a meaningful comparison of both selective and non-selective COX-2 inhibitor to evaluate their toxic effects by measuring biochemical and histological alterations of heart, liver, and kidney.

METHODS

Experimental animals

This study was conducted on 18 Sprague-Dawley rats of both sexes weighing between 250 and 300 g were used in this research. They were separated into three groups each group consists of six animals maintained in an animal house of University of Kerbala/College of Pharmacy with free access to food and water ad libitum. As the following:

1- Control group: Drenched normal saline for 1 month.
2- Ibuprofen group: Drenched 40 mg/kg/day of ibuprofen for 1 month.
3- Celecoxib group: Drenched 40 mg/kg/day of celecoxib for 1 month.
The study was conducted after obtaining approval from the Ethics Committee of College of Pharmacy/University of Kerbala.

**Experimental technique**

Drugs used including ibuprofen syrup 100 mg/5 ml (Philadelphia, Jordan), at 40 mg/kg; celecoxib capsule 200 mg (Pfizer, Switzerland), at 40 mg/kg. Celecoxib was dissolved in distilled water before administration to each animal in the group orally using a stomach cannula for 30 days. The animals were observed in their cages for clinical symptoms daily. At the end of the experimental period, the animals were anesthetized using chloroform and blood collected by cardiac puncture for serum biochemical analysis.

**Determination of biochemical parameters**

Serum was separated from clotted blood obtained by cardiac puncture. Serum enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphates (ALP), and total serum bilirubin (TSB) were determined by procedures of Sigma diagnostics, serum creatinine, and blood urea nitrogen by method of Crocker.

**Preparation of histopathological slides**

Organs such as the heart, liver, and kidney were isolated into 10% saline formalin and then subjected to histological procedures and preparation of tissue slides as directed by Banchroft et al. [21].

**Statistical analysis**

The results were represented as mean ± standard error mean. Differences between control and other experimental groups were tested for statistical significance using SPSS version (20) one-way analysis of variances. Statistically significant differences exist at p≤0.05.

**RESULTS**

**Clinical effects of NSAIDs in rats**

Animals administered with ibuprofen showed reduced food intake, sluggishness, and diarrhea with some mortality. The only symptoms seen in the celecoxib group was sluggishness and some mortality.

**Effect of the NSAIDs on the serum level of ALT, AST, ALP, and TSB in rats**

The results showed significant increase (p<0.05) in serum level of AST, ALT, ALP, and TSB in celecoxib group when compared with ibuprofen and control groups, while for ibuprofen group the results revealed significant increase (p<0.05) in serum level of AST and TSB, with insignificant difference (p>0.05) in the level of ALT and ALP when compared with control group (Table 1).

**Effect of the NSAIDs on the serum level of urea and creatinine in rats**

The results showed significant increase (p<0.05) in serum level of urea (29.66, 41.50, and 35.83) with the highest level in the ibuprofen group compared with both celecoxib and control groups, also there is insignificant difference (p>0.05) in the serum level of creatinine (0.69, 0.77, and 0.72) between the three groups (Table 1).

As shown in Fig 1a, the histological features of the normal heart indicated a normal looking endocardium and myocardium including cardiac muscle and fibers. In heart sections of ibuprofen-treated group, clarifying preserved architecture with prominent vascular congestion and mild pericardial infiltration by chronic inflammatory cell and macrophages (Fig 1b). In comparison with heart sections of celecoxib treated group clarifying more prominent vascular congestion with pericardial acute inflammatory cell infiltration (feature of pericarditis) (Fig 1c).

As shown in Fig 2a, the histological features of the normal kidney indicated a normal kidney clarifying preserved architecture of cortex and medulla, normal looking glomeruli and tubules. In comparison with kidney sections of ibuprofen treated group, clarifying vascular congestion of both cortex and medulla, with partial tubular necrosis (Fig 2b). In celecoxib pretreated group, clarifying preserved architecture vascular congestion within central venula associated with mild chronic portal tract inflammation (Fig 2c).

As shown in Fig 3a, the histological features of the normal kidney indicated a normal kidney clarifying the normal architecture of cortex and medulla, normal looking glomeruli and tubules. In comparison with kidney sections of ibuprofen treated group, clarifying vascular congestion of both cortex and medulla, with partial tubular necrosis (Fig 3b). In celecoxib pretreated group, clarifying preserved architecture vascular congestion within central venula associated with mild chronic portal tract inflammation (Fig 3c).

**DISCUSSION**

According to the present study, we observed the administration of both celecoxib and Ibufoprofen group resulted in the induction of biochemical and histopathological abnormalities of cardiac, hepatic, and renal tissues of the rats. Histologically, the cardiac manifestations are vascular congestion and mild pericardial infiltration by chronic inflammatory cell and macrophages which is more prominent in celecoxib group with feature of pericarditis, this result is in agreement with [Scotte et al., 2005] cardiovascular risk with celecoxib to prevent colorectal adenomas led to a dose-related increase in the risk of serious cardiovascular events, including death from cardiovascular causes, myocardial infarction, stroke, and heart failure [22].

Histologically, the hepatic alterations are manifested by vascular congestion within central venula and mild portal tract inflammation which is chronic in celecoxib group, also serum level reflecting significant alterations observed in the biochemical indices of rats showed that administration of celecoxib at the given doses may cause hepatotoxicity. These results are in agreement with Nachimuthu et al. [2001] observation of celecoxib in clinical trials [23]. The activities of AST, ALT, and ALP are commonly used as biochemical indicators of liver functions. Structural and functional alterations in the liver result in elevated levels in these enzymes in the circulation. The levels of these aminotransferases (ALT and AST) in serum are elevated in all liver diseases. In fact, very high levels of more than 1000 units can be seen in acute hepatitis [24].

In our present study, we clearly demonstrate that both ibuprofen and celecoxib administration lead to histological alterations in

Table 1: The effect of ibuprofen and celecoxib on the serum levels of ALT, AST, urea, creatinine, ALP, and TSB in comparison with control group

<table>
<thead>
<tr>
<th>Groups</th>
<th>Parameters</th>
<th>Mean±SEM</th>
<th>ALT (U/L)</th>
<th>AST (U/L)</th>
<th>Urea (mg/dl)</th>
<th>Creatinine (mg/dl)</th>
<th>ALP (U/L)</th>
<th>TSB (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td>35.16±1.44</td>
<td>64.83±3.28</td>
<td>29.66±1.83</td>
<td>0.69±0.03</td>
<td>280.33±27.85</td>
<td>0.28±0.02</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td></td>
<td></td>
<td>39.33±2.24</td>
<td>85.33±2.62</td>
<td>41.5±1.64</td>
<td>0.77±0.02</td>
<td>346.00±31.78</td>
<td>0.44±0.02</td>
</tr>
<tr>
<td>Celecoxib</td>
<td></td>
<td></td>
<td>51.83±2.98</td>
<td>119.33±8.46</td>
<td>35.16±1.44</td>
<td>0.72±0.04</td>
<td>512.16±51.41</td>
<td>0.52±0.02</td>
</tr>
</tbody>
</table>

*The mean difference is significant at the 0.05 level. SEM: Standard error mean, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, ALP: Alkaline phosphates, TSB: Total serum bilirubin.
kidney represented by severe vascular congestion of both cortex and medulla, with partial tubular necrosis in ibuprofen group; on the other hand, celecoxib group showed severe and diffuse vascular congestion not confined mainly in the cortex. There is focal increase in the mesangium of some glomeruli (fibrosis within glomeruli), and partial tubular necrosis, the present findings are in agreement with the work of Rania et al. (2013) demonstrate that at higher doses chronic NSAIDs contribute to the onset of glomerular changes in the filtration barrier [25]. Celecoxib resulted in glomeruli basement membrane thinning, slit pore diameter and foot process density reduction, and increased mesangial area, but at comparable doses, ibuprofen is more detrimental than celecoxib, causing severe necrotizing pyelonephritis.

CONCLUSION

NSAIDs are the mainstay therapy in controlling of pain and fever by inhibiting COX enzymes mediated inflammatory response so that the chronic use of these drugs makes the patients exposed to adverse and toxic effects of it, and by making comparison of both selective (celecoxib) and non-selective COX-2 inhibitor (ibuprofen) to evaluate their toxic effects by measuring biochemical and histological alterations which showed significant findings for heart, liver, and kidney.

ACKNOWLEDGMENT

Special gratitude is expressed to the department of pharmacology and toxicology that are represented by the headmaster and the staff for providing facilities required for this research, and all who participates in this work.

AUTHOR’S CONTRIBUTIONS

Noor D. Aziz contributed to the idea of the research, write, and coordinate the work between the other members. Mazi H. Ouda contributed to drug dosing to the rats and follow-up of the animal for 30 days (the research period). Moayad Mijbil Ubaid contributed to biostatistics of the research.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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