Data Article

Lipidomics dataset of sonication-induced traumatic optic neuropathy in mice

Ronaldo Nuesi, Ryan A. Gallo, Galina Dvoriantchikova, Daniel Pelaez**, Sanjoy K. Bhattacharya*

Bascom Palmer Eye Institute, Department of Ophthalmology, University of Miami, Miami, FL, 33136, USA

Abstract

Traumatic optic neuropathy (TON) is the loss of vision secondary to trauma. Approximately two weeks after traumatic damage, diffuse retinal ganglion cell loss and axon degeneration of the optic nerve are exhibited [1]. Here we present the changes that occur in the optic nerve lipidome of two-month-old C57BL/6J mice following sonication-induced TON (SI-TON), which closely models the indirect clinical mechanism in TON. Optic nerves were harvested at three time points following injury: 1-day, 7-days, and 14-days for comparison with the control group (uninjured optic nerves from 2-month-old mice). The optic nerves were subjected to mass spectrometry and bioinformatic analysis using LipidSearch 4.1.3 and Metaboanalyst 4.0. This data pertains to the lipidome at each time point following indirect trauma to the optic nerve. The data presented here will augment investigation into the neurodegenerative process. The data is available at Metabolomics Workbench [http://www.metabolomicsworkbench.org (Project ID: PR000859)].

© 2020 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

1. Data description

Here we present a lipid profiling of the optic nerve following sonication-induced trauma in two-month-old C57BL/6J mice and that from the control mice. Mice were placed in a sound-proof...
chamber and exposed to a 500 msec sonic shock from a microtip probe as shown in Fig. 1. Optic nerve samples were collected at 1 day, 7 days, and 14 days post sonication and subjected to Methyl-Tert-Butyl Ether/Methanol (MTBE) lipid extraction. BCA Assay was used to aliquot lipids corresponding to a 30 μg by protein in each sample. Lipids were re-suspended in Chloroform: Methanol (1:1) and processed through untargeted liquid chromatography Q-Exactive Orbitrap tandem mass spectrometry (LC-MS/MS). Relative quantification was performed using lipid peaks of the species identified with LipidSearch 4.1.3 software. Data from LipidSearch 4.1.3 was formatted and exported to Metaboanalyst 4.0 for statistical analyses as shown in Fig. 2. Labeling of samples were as in Table 1. A list of lipid nomenclature used can be found in Table 2 and identified lipids can be found in Supplementary Table S1.

2. Experimental design, materials, and methods

2.1. Animals

All animals were treated in accordance with the Association for Research in Vision and Ophthalmology (ARVO) statement for the use of animals in ophthalmic and vision research, and were used under protocols approved by the University of Miami, Institutional Animal Care and Use Committee.
(IACUC). C57BL/6J mice were obtained from Jackson Laboratory (Bar Harbor, ME, USA). Mice were maintained in a temperature-regulated environment with a 12-h light, 12-h dark cycle, and all mice were fed ad libitum. Two-month-old mice were used for this dataset.

2.2. Sonication-induced traumatic optic neuropathy model

Sonication-induced traumatic optic neuropathy (SI-TON) model was performed as described previously [1]. Briefly, TON was induced in two-month-old C57BL/6J mice with a Branson Digital Sonifier 450 (Branson Ultrasonics, Danbury, CT, USA) by a 3mm microtip probe in an acoustic soundproof enclosure chamber. Mice were anesthetized with vaporized isoflurane supplied with oxygen in an induction chamber. The fur adjacent to each mouse’s supraorbital rim was shaved, and each mouse was placed on the stage of a sound-proof enclosure equipped with an anesthesia mask for continuous supply of anesthesia. The stage was adjusted so that the microtip probe was in direct contact with the supraorbital rim above the insertion point of the optic nerve into the optic canal. Only left optic nerves were injured. The sonicator was programmed to deliver a 500 msec shock at a 35% or 40% amplitude, which results in a 230 to 250-μm oscillation according to the manufacturers’ specifications. After sonication, mice were placed in a new cage with thermal support until fully recovered.

2.3. MTBE lipid extraction

Optic nerves were carefully dissected at 1 day, 7 days, and 14 days post exposure, beginning from the optic nerve head and continuing on until reaching the optic chiasm. Methyl-tert-butyl ether (MTBE) extraction was then performed as described with some modifications [2]. Briefly, optic nerves were immersed in 400 µl of Methanol + BHT then snap frozen and thawed for five-minute cycles using liquid nitrogen and a 37°C water bath until completely homogenized. Samples were transferred to amber glass vials and 1.3 mL of MTBE was added. They were incubated in the dark at 4°C on an orbital shaker overnight. The following day, samples were transferred to a centrifuge tube and 417 µl of 0.15 M Ammonium Acetate was added. They were then centrifuged for 10 min at 2000 × g at 4°C. The organic layer (upper) was collected, transferred to 2mL glass vials and dried in a centrifugal vacuum concentrator. Samples were re-suspended in 50 µl of 1:1 Chloroform: Methanol and stored in –20°C until further processing.

2.4. High performance liquid chromatography and mass spectrometry

Lipids were analyzed by liquid chromatography electrospray tandem mass spectrometry (LC-MS/MS) using an Accela HPLC system and an orbitrap mass spectrometer (Q Exactive, Thermo Scientific, Waltham MA). An Acclaim 120 C18 3μm column (Thermo Scientific) was used with LC-MS grade Methanol: Water 60:40 v/v with 10mM Ammonium Acetate and Methanol Chloroform 60:40 v/v with 10mM Ammonium Acetate, as solvent A and B, respectively. A Heated Electrospray Ionization Source (HESI) was operated at a spray voltage of 4.4kV, a HESI vaporization

Fig. 1. Schematic diagram of C57BL/6J mice exhibiting lipidomic changes following ultrasonicated ocular trauma. A probe was placed on the supraorbital rim and 500msec pulses were transmitted with 60–80 J of force. Mice optic nerves were harvested at one day, seven days, and fourteen days after sonic wave exposure. MTBE extraction was performed and lipids collected from the upper organic layer. Lipid changes in the optic nerve were analyzed using mass spectrometry and a heat map was generated.
Fig. 2. Lipidome heatmap. Relative abundance of lipid species with control (no exposure) and 1-day, 7-days and 14-days post exposure to sonication. All outliers were included and 56 significant species were identified by One Way ANOVA, (p-value set to 0.05).
Table 1

Sample Identification. 31 optic nerve samples were used from 15 males and 16 females. Each sample was run twice in positive mode and twice in negative mode.

| Sample | Exposure | Days Post Exposure | Sex | ESI Mode |
|--------|----------|--------------------|-----|----------|
| C1     | No Sonication | 0                 | M   | Pos      |
| C1     | No Sonication | 0                 | M   | Neg      |
| C2     | No Sonication | 0                 | M   | Pos      |
| C2     | No Sonication | 0                 | M   | Neg      |
| C3     | No Sonication | 0                 | M   | Pos      |
| C3     | No Sonication | 0                 | M   | Neg      |
| C4     | No Sonication | 0                 | M   | Pos      |
| C4     | No Sonication | 0                 | M   | Neg      |
| C5     | No Sonication | 0                 | F   | Pos      |
| C5     | No Sonication | 0                 | F   | Neg      |
| C6     | No Sonication | 0                 | F   | Pos      |
| C6     | No Sonication | 0                 | F   | Neg      |
| C7     | No Sonication | 0                 | F   | Pos      |
| C7     | No Sonication | 0                 | F   | Neg      |
| C8     | No Sonication | 0                 | F   | Pos      |
| C8     | No Sonication | 0                 | F   | Neg      |
| D1_1   | Sonication  | 1                 | M   | Pos      |
| D1_1   | Sonication  | 1                 | M   | Neg      |
| D1_2   | Sonication  | 1                 | M   | Pos      |
| D1_2   | Sonication  | 1                 | M   | Neg      |
| D1_3   | Sonication  | 1                 | M   | Pos      |
| D1_3   | Sonication  | 1                 | M   | Neg      |
| D1_4   | Sonication  | 1                 | M   | Pos      |
| D1_4   | Sonication  | 1                 | M   | Neg      |
| D1_5   | Sonication  | 1                 | F   | Pos      |
| D1_5   | Sonication  | 1                 | F   | Neg      |
| D1_6   | Sonication  | 1                 | F   | Pos      |
| D1_6   | Sonication  | 1                 | F   | Neg      |
| D1_7   | Sonication  | 1                 | F   | Pos      |
| D1_7   | Sonication  | 1                 | F   | Neg      |
| D1_8   | Sonication  | 1                 | F   | Pos      |
| D1_8   | Sonication  | 1                 | F   | Neg      |
| D7_1   | Sonication  | 7                 | F   | Pos      |
| D7_1   | Sonication  | 7                 | F   | Neg      |
| D7_2   | Sonication  | 7                 | F   | Pos      |
| D7_2   | Sonication  | 7                 | F   | Neg      |
| D7_3   | Sonication  | 7                 | F   | Pos      |
| D7_3   | Sonication  | 7                 | F   | Neg      |
| D7_4   | Sonication  | 7                 | F   | Pos      |
| D7_4   | Sonication  | 7                 | F   | Neg      |
| D7_5   | Sonication  | 7                 | M   | Pos      |
| D7_5   | Sonication  | 7                 | M   | Neg      |
| D7_6   | Sonication  | 7                 | M   | Pos      |
| D7_6   | Sonication  | 7                 | M   | Neg      |
| D7_7   | Sonication  | 7                 | M   | Pos      |
| D7_7   | Sonication  | 7                 | M   | Neg      |
| D14_1  | Sonication  | 14                | M   | Pos      |
| D14_1  | Sonication  | 14                | M   | Neg      |
| D14_2  | Sonication  | 14                | M   | Pos      |
| D14_2  | Sonication  | 14                | M   | Neg      |
| D14_3  | Sonication  | 14                | M   | Pos      |
| D14_3  | Sonication  | 14                | M   | Neg      |
| D14_4  | Sonication  | 14                | M   | Pos      |
| D14_4  | Sonication  | 14                | M   | Neg      |
| D14_5  | Sonication  | 14                | F   | Pos      |
| D14_5  | Sonication  | 14                | F   | Neg      |
| D14_6  | Sonication  | 14                | F   | Pos      |
| D14_6  | Sonication  | 14                | F   | Neg      |
| D14_7  | Sonication  | 14                | F   | Pos      |
### Table 1

| Sample | Exposure | Days Post Exposure | Sex | ESI Mode |
|--------|----------|--------------------|-----|----------|
| D14_7  | Sonication | 14                | F   | Neg      |
| D14_8  | Sonication | 14                | F   | Pos      |
| D14_8  | Sonication | 14                | F   | Neg      |

### Table 2

LipidSearch nomenclature.

| Group                  | Abbreviations | Lipid Name                                      |
|------------------------|---------------|-------------------------------------------------|
| **P-Choline**           |               |                                                 |
| LPC                    | lysophosphatidylcholine                           |
| PAF                    | platelet-activating factor                        |
| PC                     | phosphatidylcholine                               |
| MePC                   | Methyl phosphatidylcholine                        |
| **P-Ethanol Amine**     |               |                                                 |
| LPE                    | lysophosphatidylethanolamine                      |
| LdMePE                 | lysodimethylphosphatidylethanolamine              |
| PE                     | phosphatidylethanolamine                          |
| BisMePE                | Bis-methyl phosphatidylethanolamine               |
| dMePE                  | dimethylphosphatidylethanolamine                  |
| **P-Serine**            |               |                                                 |
| LPS                    | lysophosphatidylserine                            |
| PS                     | phosphatidylserine                                |
| BisMePS                | Bis-methyl phosphatidylserine                     |
| **P-Glycerol**          |               |                                                 |
| LPG                    | lysophosphatidylglycerol                          |
| PG                     | phosphatidylglycerol                              |
| BisMePG                | Bis-methyl phosphatidylglycerol                   |
| **P-Inositol**          |               |                                                 |
| LPI                    | lysophosphatidylinositol                          |
| PI                     | phosphatidylinositol                              |
| PIP                    | phosphatidylinositol                              |
| PIP2                   | phosphatidylinositol                              |
| PIP3                   | phosphatidylinositol                              |
| **P-Ethanol**           |               |                                                 |
| LPEt                   | lysophosphatidylethanol                           |
| PEt                    | phosphatidylethanol                               |
| **P-Acid**              |               |                                                 |
| LPA                    | lysophosphatidic acid                             |
| BisMeLPA               | Bis-methyl lysophosphatidic acid                  |
| PA                     | phosphatidic acid                                 |
| BisMePA                | Bis-methyl phosphatidic acid                      |
| cPA                    | cyclic phosphatidic acid                          |
| **P-Methanol**          |               |                                                 |
| LPMe                   | lysophosphatidylmethanol                          |
| PMe                    | phosphatidylmethanol                              |
| **Sphingolipids**       |               |                                                 |
| SM                     | sphingomyelin                                     |
| LSM                    | lysosphingomyelin                                 |
| phSM                   | sphingomyelin (phytosphingosine)                  |
| **Neutral glycerolipid**|               |                                                 |
| MG                     | monoglyceride                                     |
| DG                     | diglyceride                                       |
| TG                     | triglyceride                                      |
| **Fatty Acid**          |               |                                                 |
| FA                     | fatty acid                                        |
| **Cardiolipin**         |               |                                                 |
| CL                     | Cardiolipin                                       |
| **Sphingoid base**      |               |                                                 |
| So                     | Sphingosine                                        |
| SoP                    | Sphingosine phosphate                             |
| **Neutral Glycosphingolipids** |         |                                                 |
| SoG1                   | Glucosylsphingosine                               |
| CerG1                  | Simple Glc series                                 |
| CerG2                  | Simple Glc series                                 |
| CerG3                  | Simple Glc series                                 |
| CerG2GNAc1             | Simple Glc series                                 |
temperature of 275 °C, a sheath gas pressure of 45 arbitrary units, and an auxiliary gas flow of 15 arbitrary units. The ion transfer tube was kept at a temperature of 350 °C. The scan range was set at 150–1500 m/z. The gradient ran at 35%–100% Solvent B for 13 minutes and then was held at 35% solvent B for 2 minutes. The gradient was then brought up to 100% solvent A for 3 minutes and held for 2 minutes.

2.5. Lipid identification and relative quantification

Raw data from LC-MS was uploaded to LipidSearch 4.1.3 (Thermo Scientific). The search parameters were as follows: productsearch, precursor (5/5) ppm, intensity threshold 1.0%, M-Score 0.0. Quantitation and Toprank filter were turned on, Main node filters were set to Main Isomer Peaks, and ID quality was graded from A-D. All target classes were selected with the exception of fatty esters, glycoglycerolipids, and deuterated glycerolipids. All adducts in negative mode were selected, and all adducts in positive mode were selected with the exceptions of Li+, (CH3CH2)3NH +, and (CH3) 2NH2 +.
2.6. Data analysis

After peaks were identified, every sample was aligned to calculate the unassigned peaks. During alignment, lipid identification was filtered by grading from A-C. A few peaks in the following lipid classes of CerG1, PC, LPC, PE, TG, and ST were rejected as false positives and removed. Data was placed into four groups (Control, One day, Seven Days, Fourteen Days) and statistical analysis was performed with Metaboanalyst 4.0. No missing values were detected. Data was normalized to the reference group (control), log transformation was applied, and heat maps were then generated (Fig. 2).

Acknowledgments

This dataset was supported in part by NIH grant U01EY027257 and an NIH Center Core Grant P30EY014801, a Research to Prevent Blindness Unrestricted Grant and the Dr. Al-Rashid Vision Research Centre Endowment (DP). Metabolomics workbench is an effort of NIH Common Fund’s Metabolomics Data Repository and Coordinating Center supported by U2C DK119886.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2020.105147.

References

[1] W. Tao, et al., A novel mouse model of traumatic optic neuropathy using external ultrasound energy to achieve focal, indirect optic nerve injury, Sci. Rep. 7 (1) (2017) 11779.

[2] V. Matyash, et al., Lipid extraction by methyl-tert-butyl ether for high-throughput lipidomics, J. Lipid Res. 49 (5) (2008) 1137–1146.